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Welding Engineering

OHIO STATE University has taken a forward step in its inauguration of a four-year course in welding engineering. This educational program will help to satisfy the need for more engineers trained in welding design. Those of our readers who have had an opportunity to study the outline of the curriculum as published on page 22 of the June, 1939, issue of THE WELDING ENGINEER will agree that emphasis has been placed upon the young engineer's design background.

We also believe that most of our readers will agree that our greatest deficiency, at the present stage of welding development, lies in the lack of engineers properly trained in the technical details of welding design. As Dean Charles E. MacQuigg points out, there has been little opportunity so far for design practices to become rationalized. This is due in large part to the rapid growth of welding. "Until lately the operations have been largely empirical. In view of the quite involved relationships between the nature of the metal to be welded, the design of the joint, the practice used in manipulation of the torch or electrode, the nature of the filler metal, the heat treatment effects and other important factors, the routine production of welds has become a highly specialized practice," says Dean MacQuigg.

Outstanding leaders in our industry have been very active in developing interest in welding among the engineers who have a design responsibility. This kind of leadership within our own industry is certainly very constructive because it will advance welding more rapidly than any other type of promotional effort at the present stage of development.

We feel certain that the educational institutions will take their cue from the rapid growth of welding and formulate technical training programs to help supply the increasing demand for engineers trained in welding design.

Good News

HAVE YOU EVER had the experience of thinking about some friend or relative and then shortly thereafter find them calling you on the telephone or ringing your doorbell? We experienced a somewhat similar feeling since publication of an editorial last month on welded steel buildings. The lack of standard shop details to assist the structural engineer was commented upon as being a really serious obstacle. We felt that the engineer is handicapped in designing welded connections because of this lack of information.

We were pleasantly surprised a few days ago to receive the following letter from F. H. Frankland, chief engineer of the American Institute of Steel Construction: "For the past year the A.I.S.C. Committee on Welding has been working on the development of standard connection details for fusion welded building steel. The pressing need for such standard details has been realized by the American Institute of Steel Construction, and it is our intention to publish before the end of the year the standard details developed by our Committee. These details will be added to from time to time as developments warrant."

Surely the prospects for welded buildings will become much brighter when these welded connection details are made available through the Committe on Welding of the A.I.S.C. We welcome the good news.

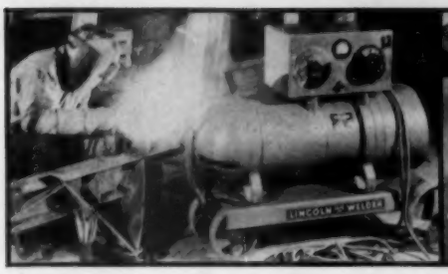
Hard-Surfacing

THE PROBLEM OF wear resistance is indeed very old. Experience has demonstrated that surface hardness is definitely related to wear resistance, and, therefore, we strive for greatest surface hardness in all parts of equipment which have to withstand abrasion. By means of welding it has become possible to build up wearing parts with a deposit of an exceptionally abrasion-resistant metal. In other words, metals can be used more economically because of welding. Heavy investments in equipment can be conserved and profits maintained through application of hard-surfacing materials.

It is important, however, that proper application of hard-surfacing alloys is made, otherwise there is no true economy. As the author points out in his paper "Hard Surfacing Applications," published in this issue, it is necessary to study the types of hard-facing alloys commercially available and select an alloy which will best meet the service demands. Our readers will find Table 1 on page 17 an exceptionally useful guide in the selection of proper hard-facing alloys. This information should prove extremely helpful to welding repair shops and we hope will remove some of the guess-work from hard-facing applications. Scientific selection of proper material will make the welding customer more satisfied and this is the only sound basis on which to build any business.

There seem to be plenty of money-saving applications in all industries. Those engaged in welding repair work should conduct a survey of their welding opportunities in this profitable market. We use the word "profitable" advisedly in this connection, because hard-facing jobs can be profitable both to the welding shop and to the owner of the equipment. The men who have made a success of the repair business, stress the importance of studying all hard-surfacing business opportunities. If you are a shop owner you cannot afford to neglect this field.

WHAT DO YOU KNOW *about arc welding machines?*

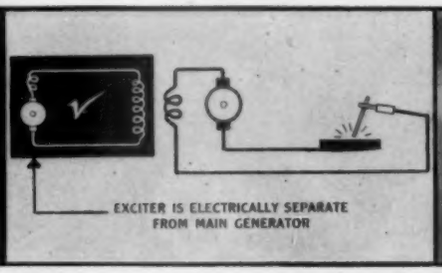


1. How can large electrodes be used for faster welding without danger of burnout? Answer: By using a *"Shield-Arc."* Its motor provides positive and complete protection from burnout, making possible sustained operation at high average loads.

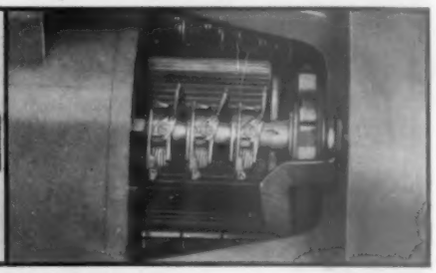
2. What is the full meaning of *"Shield-Arc's"* Self-Protection? It prevents burnout *from any cause*...sustained overload, single-phase running, high or low line-voltage, phase unbalance or impaired ventilation...avoiding delays and expense.

3. How can the TYPE of welding arc be varied to suit various joints and working conditions for maximum speed and quality on *every* job? Answer: With a volt-ampere-slope control. Only *"Shield-Arc"* has this "Job Selector."

4. What welder provides *continuous* selection of both the TYPE of arc and the AMPERAGE with all settings marked right on the control dials? Answer: *"Shield-Arc."* This simplifies "setting" and minimizes welding cost.



5. How does Lincoln Separate Excitation improve welding? Answer: It acts like an electrical flywheel, providing constant power for a steady arc under all welding conditions, assuring easier welding and quality results.



6. How can you assure long life for brushes and commutator? Answer: Buy a *"Shield-Arc"* and eliminate the need for brush-shifting. The brushes are fixed at the factory for *permanent* sparkless operation. They seldom require attention.

7. What advantage has *"Shield-Arc's"* Laminated Magnetic Circuit over solid iron? Answer: It quickens the generator's response to changing conditions at the arc. Assures faster welding and less spatter under all conditions.

8. What two types of polarity switches are used on welders? Answer: One type is in the welding circuit. The other (*"Shield-Arc's"*) is in the excitation circuit —it carries no heavy current to burn contacts and can be used as a disconnect.

9. Why can thin-gauge material be welded so effectively and economically with a *"Shield-Arc"* Welder? Answer: Because its Dual Continuous Control makes available extremely low current values without need for wasteful resistances.

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Fig. 1—This worn cat-head (oil drilling rig), hard-faced with non-ferrous alloy, will last 3 times longer.

How to select
the correct alloy for

Hard-Surfacing Applications

★ To meet requirements of hardness, toughness, and shock resistance, various alloys of widely different compositions have been developed

By CHARLES E. MacQUIGG*
Dean of the Engineering School, Ohio State University, Columbus, Ohio

MAN'S DESIRE to harden metal is older than recorded history and obviously would date from the moment when he found his implements were not equal to the demands of service. This need for hardness in metal may be divided roughly into two main classifications: (a) need for hardness throughout—for purposes of greater strength or elasticity of the whole implement or member, and (b) need for surface hardness alone. Among metals hardened throughout, we would have, for example, the case of a strong steel needed to transmit stresses or resist deformation. In metals only surfaced-hardened, the chief need is for resistance to wear.

Surface-hardening means increasing the hardness of the superficial layers of the original metal in place. Hard-surfacing means adding suitable metallic layers to the original surface.

Fig. 2—Setting tungsten carbide inserts in place on a fish-tail oil well bit.

THREE TYPES OF WEAR—We must confess that there is much still unknown regarding the phenomena of wear and the methods of combating it. Wearing of a surface consists of removal of the superficial layers and can be caused by any of the following:

(a) Actual detachment of the particles by scraping or cutting action, as in sandblasting.

(b) Changing of the nature of the surface by chemical action and removal of the product. This might occur in corrosion.

(c) Seizing or galling of the surface, in which case the parts in contact may unite in spots as though actually welded.

Almost any combination of these types of wear might be present. Not long ago it was found that in a simple grinding action, the nature of the atmosphere had a marked effect on the

*Condensed from special lecture delivered before 39th Annual Convention, International Acetylene Association, Houston, Texas.

Fig. 3—This hard-faced oil well bit is still out to gauge after drilling 2382 ft. in the East Texas field.

wear of the metallic surface. The absence of oxygen materially reduced the wear.

In general we get the best resistance to wear with the greatest surface hardness and therefore we strive to attain that property to the maximum extent compatible with other qualities needed. Hardness is usually measured by resistance to deformation and so our objective methods generally consist of the measurement of the permanent deformation of the metal surface under a given pressure, applied to a carefully standardized implement — as a hardened steel ball or a diamond point. Examples of such test methods are the Brinell, the Rockwell, and the Vickers. Still another type of test depends on a quality of resiliency or "springiness" of the surface which in turn is related to "hardness" (elasticity). The Shore Scleroscope is an example of an instrument for making this type of test.

Hard-Surfacing

Hard-surfacing or "hard-facing," a process of comparatively recent development, consists in welding on to wearing parts a facing, edge or point of a hard metal, exceptionally resistant to abrasion. By this method, metal surfaces which normally wear away rapidly in service are protected by a layer of special alloy possessing unusual wear resistance. To meet adequately the various requirements of hardness, toughness, shock resistance and other qualities, various hard-facing alloys of widely different compositions have been developed. Broadly speaking, however, these may be divided into four groups: (1) low-alloy steels, (2) high-alloy steels, (3) non-ferrous alloys, and (4) tungsten carbides and borides.

GROUP 1. For the first group there is no sharp definition of composition. If the alloying constituents are less than approximately 5%, it would be accepted as low-alloy steel in connection with hard-surfacing. While not as wear resistant as the other groups about to be described, it has some advantage in toughness and shock resistance. Manganese, chromium, molybdenum, vanadium and tungsten are the most commonly used alloying elements, generally with carbon about .03 to 0.6%.

GROUP 2. If the alloying elements are present in excess of approximately 10%, the hard-facing material falls in the second group. These steels almost invariably contain high-chromium for extra wear resistance. Manganese, cobalt, tungsten and nickel may also be present in this group. Somewhat more expensive than the low-alloy types, this group is notable for markedly greater wear resistance than the low-alloy group. Due to longer life of these metals, they frequently are more economical in the long run than the less expensive metals.

GROUP 3. Non-ferrous alloys of cobalt, chromium and tungsten are included in the third group. They are available in several different grades, all highly resistant to wear, but having a spread in strength and toughness which makes them suitable for a wide range of hard-facing applications. Because of their non-ferrous composition, these alloys have the unique property of red hardness, that is, they retain their original hardness practically unimpaired at elevated temperatures.

GROUP 4. The fourth group consists of the so-called diamond substitutes, the hardest and most wear-resistant of all hard-facing materials. Some of these are almost pure fused tungsten carbides, while others contain 90 to 95% tungsten carbide, the remainder usually being cobalt, nickel or iron. These diamond substitutes are furnished in the form of small castings, known as inserts, and in the form of welding rods in which the hard particles are packed in steel tubes. The tungsten carbide inserts are welded and imbedded into the wearing surfaces of oil well drilling bits and similar tools by means of other metals. Because of their extreme refractoriness, these compounds are not melted or otherwise greatly affected by the oxy-acetylene flame; they are "wetted" by the molten metals and thus become fused in place — much as a lump of tinned steel might be soldered to a piece of copper. Thus they are held in place without difficulty on the wear-resisting surface.

Selecting the Proper Alloy

In order to select intelligently the correct hard-facing material for any particular application, it is necessary to determine those factors which cause

Fig. 4—Applying hard-facing alloy to the seating surface of a 9 in. diameter valve disk.

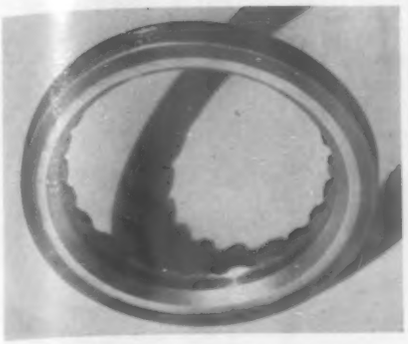

Fig. 5—This hard-faced exhaust valve seat insert will not require regrinding or refinishing after a run of 150,000 miles or more.

the deterioration of the wearing part. Thus, if there is an element of corrosion involved, the material may differ essentially from one which might have to resist shock alone. Again, the nature of the surface must be taken into account. Must it be smooth—or will roughness (as in a cutting surface) be advantageous? Finally, cost must always be considered, although first cost may be subordinated to length of life. Table 1 is an effort to depict the groups with relation to their chief attributes. Obviously no such representation can be made wholly rigid, but it will be suggestive of the main factors to be kept in mind when selecting material for a given application.

Table 1

Guide to Selection of Hard-Facing Alloy
Group 1—Low-Alloy Steels
Group 2—High-Alloy Steels
Group 3—Non-Ferrous Alloys
Group 4—Tungsten Carbides

Characteristic of Deposit	Group Number			
Cold Hardness	4	2	3	1
Red Hardness	4	3	2	1
Resistance to Impact	1	2	3	4
Corrosion Resistance	3	2	1	4
Smoothness of Deposit	3	1	2	4
Ability to Scour	4	2	3	1
Thinness of Welding	3	2	1	4

Three examples will serve to illustrate the use of Table 1. Mining equipment used for crushing rock and ore is subjected to constant battering and impact. Here resistance to shock and impact is all-important, with hardness only a secondary consideration. This should indicate a preference for hard-facing alloys of Groups 1 or 2. In practice, these materials have proved to be most suitable for this type of service.

Valves for handling high-temperature, high-pressure steam, gas, oil and acids must resist heat, erosion, and corrosion. It has been found that alloys of Group 3 work extremely well for the seating surfaces of these valves because of their red hardness and corrosion resistance.

No matter how ideal their other properties, alloys of Groups 4 would not be suitable for this service because of the extreme roughness of their deposits. However, the very nature of the rough deposits of the Group 4 alloys results in an extremely efficient digging edge. This factor, together with the greater hardness of these materials, is the reason for their widespread use on oil well drilling tools, dredge cutter blades and other parts coming in contact with earth, sand and gravel.

While any of the standard methods of fusion welding may be applied to hard-surfacing, I will confine this paper to the special advantages of the oxy-acetylene process. In the first place, the torch allows a close control of the operation and results in a smooth deposit. Particles of scale and foreign matter may be floated out. Ease of control permits the building of edges and corners, thus facilitating subsequent grinding to close tolerances. The torch seems to facilitate manipulation of those hard-facing materials which must be "puddled in" to the surface—as well as those which are "sweated" onto the surface; flexibility of the heating flame permits either set of conditions. Finally, the technique is not difficult and may be learned quickly by any proficient welder.

All plain carbon and low-alloy steels may be hard-faced, provided carbon content is not substantially in excess of 0.5%. Higher carbon and alloy contents require, under some circumstances, special heat-treatments subsequent to the operation of surfacing, and preheating of the part to be surfaced may be required. Gray cast-iron and alloy cast-irons are readily hard-surfaced. On the other hand, brass, copper or bronzes cannot be hard-surfaced because of their relatively low melting points.

Hard-Facing Applications

In the oil industry, it is interesting to trace the parallel development of the hard-facing process and oil well drilling tools—tools of more intricate design and made of better materials. It is a long step from the shop-dressed and tempered fishtail bit to the latest type of cast or forged bits having multiple cutting and reaming blades. Such intricate tools as are available today would probably never have been feasible without the extra long life imparted to them by hard-facing materials. As an example, it has been possible to cut drill consumption in certain East Texas wells, from 84 to 14 bits. In soft formations as much as 2,000 ft. per bit is not an unusual record, and even in considerably harder formations, bits faced with diamond substitutes may average 600 to 700 ft. The use of hard-facing in the oil and gas industry is not, however, confined to rotary bits. Pump shafts, pump runners, shaft sleeves, catheads, sidetracking mills, core heads, go-devils, and refinery valves seating surfaces all may be economically protected by hard-facing.

Just a brief word should be said about these refinery valves. During the past few years there has been a definite trend toward the use of hard-

Fig. 6—Lips of this clam-shell bucket were hard-faced with 25 lbs. of high alloy steel welding rod.

Fig. 7—Hard-faced road grader blades develop a self-sharpening action which prolong their service life.

faced seating surfaces for valves, where operating conditions are such as to demand that seat and disk material be free from seizing and galling, and at the same time be corrosion resistant. Hard-faced valves have proved particularly dependable for handling high-temperature, high-pressure steam, as well as for handling hot, high-sulphur crudes containing free SO_2 and SO_3. These valves are free from scoring and wire-drawing, remain tight, and insure leak-proof dependable performance.

The agricultural industry was one of the first to adopt hard-facing. Plowshares not only last 3 to 7 times longer when hard-faced, but also required less sharpening and maintain a cleaner cutting edge. Tests carried out by several state university agricultural experiment stations have definitely proven that plowshare costs are reduced by at least one-half.

The automotive industry, a pioneer in many metallurgical improvements, has adopted hard-facing for not only its manufacturing machinery, but also for wearing parts of bus and truck motors. Probably the most outstanding example of the use of hard-facing material in the automotive field is for armoring exhaust valve seats. Most of the manufacturers of heavy-duty trucks and buses have standardized on hard-faced exhaust valve seat inserts, because these seats last longer, require less attention and reduce valve grinding and adjustment to a minimum.

One of the most extensive uses of hard-facing is for protecting the teeth of dipper buckets, dragline buckets, clamshell buckets and ditching machines. The wear on equipment designed to handle rock, sand, and gravel is so terrific that it is only natural to expect use of hard-facing materials for wearing parts. Hardly a single piece of machinery used in building and maintenance of roads will not operate more efficiently and economically when hard-faced. Road scraper blades, sub-grader blades, scarifier teeth, plows, tractor treads, crushing machinery, and tar scrapers for the seams of concrete roads are all hard-faced with successful results.

In other industries, hard-facing applications are just as many and just as varied. Brick dies, cement grinder rings, coke pusher shoes, steel mill shear blades, lumber mill shredder knives and coal undercutter bits are typical of the variety of parts which are economically hard-faced.

Welded Reinforcing Steel For Large Concrete Pipe

By W. E. ARCHER

★ Welding has played a very important part in the construction of the Colorado River aqueduct which will supply water to Southern California. Much of the covered conduit sections, as well as the inverted siphons, are made of steel-lined and steel-reinforced concrete pipe. The United Concrete Pipe Corp. of Los Angeles, Calif., fabricated a large share of the pipe for this project. Most of this pipe was precast, but as later described, some of it was field fabricated. This article deals principally with welding processes and operations in the plant fabrication of pre-cast reinforced concrete pipe.

Fig. 1—Equipment for testing welded pipe sections under 10 psi. air pressure. Any leaks detected were marked and re-welded.

Steel lines for pipe ranged from 16 gauge to ¼-in. plate, depending upon the pressure to which the pipe section would be subjected. With the heavier plate, sheets were first run through an automatic planer to bevel the edges preparatory to welding. No beveling was done on thinner sheets. This pipe averaged about 10 ft. in diameter (inside measurement), and was 100% electrically welded. Eight sheets of plate making up each joint were laid together and fed on a traveling platform through an automatic electric welder. Length of joints was 12 ft. In this welding operation a heavily-coated coiled rod was used.

Upon completion of assembly of plates making up the joint, the long welded sheet was run through a roller and brought to a cylindrical shape. The final weld was made by means of an automatic electric clamp-type machine. In this operation, welding was done with a bare rod, with flux applied in ribbon form, and folded about the rod by a mechanical arrangement as the welding progressed.

Lock joint rings were next welded at each end, and the joint tested for leaks by 10 lbs. air pressure. This was done by setting the section of pipe over a specially made cylinder on which a head was placed. Then both top and bottom of the pipe were sealed with rubber gaskets, and air pressure applied. Soap suds were used to detect possible leaks. When any leaks were detected, they were marked and re-welded. Testing and welding of leaks is shown in Fig. 1. Note the head for applying air test, and also the welded frame on which welders and testers can stand. Upon completion of this operation, the pipe liner is ready for the "cage" of reinforcing steel.

The "cages," or steel reinforcing structures, referred to, are constructed

Fig. 2—Welding of the pipe reinforcing "cage" was speeded up by good teamwork.

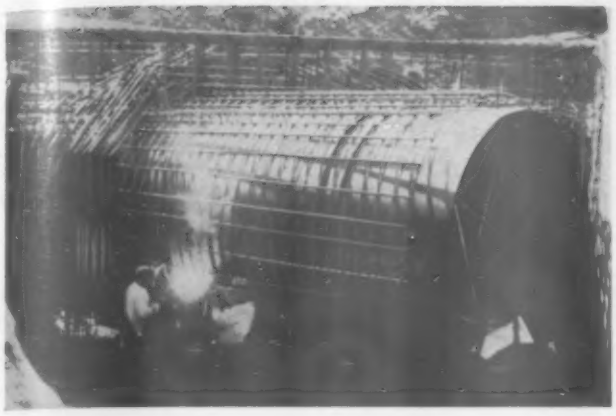

Fig. 3—This gives some idea of the massive network of welded reinforcing steel used on some of the field installations.

of various sized smooth rods, ranging from ⅜ to 1⅛ in. in diameter, depending upon their location and function in the structure. These rods are first placed on a table and sheared to exact length, then rolled into a circle and welded in a special low-voltage, high-amperage, transformer type butt welder.

The welds are then tested to within a few pounds of the yield point of the parent metal in a tensile testing machine. Circumferential rings used in these cages are formed into two different shapes, each designed for a special purpose. One set is elliptical in shape, while the other is perfectly round, the former to provide strength for the internal pressure on the pipe, the latter to reinforce the pipe itself and to assist in supporting the back-fill. Elliptical rings were formed by means of a special shaping jig operated by a hydraulic ram.

Fabricating Procedure

In fabricating these reinforcing structures the first step is to set the "can" inside the required number of rods previously placed in a pile for the purpose. Then vertical rods with "stand-off" bars, to hold the circumferential rings the proper distance from the steel cylinder, are welded to the cylinder. Next the rings are raised, one at a time, properly spaced, and welded into place.

The teamwork of the four pairs of welders is notable, moving with machine-like precision, they weld simultaneously at their respective positions about the structure, bringing the "cage" to rapid completion. (See Fig. 2.) Angle sections were somewhat more difficult in assembly than the straight joints.

The massive network of welded reinforcing steel used in some of the field installations, is shown in Fig. 3. At this location a "Y" has been installed, one section of which is 10 ft. in diameter and the smaller section 9 ft. 8 in. In this network 16 tons of reinforcing steel, ranging from ½ in. to 1 in. round, and square bars ranging up to 1¼ in. in thickness, were interlaced and braced and secured into one solid unit by arc welding. All angles, Y's and irregular sections of pipe were field poured. The steel liners and "cages" for these, however, were shop fabricated and transported to the point of installation.

Supervision of the major part of the plant work was under direction of John Huber, plant superintendent for United Concrete Pipe Corp.

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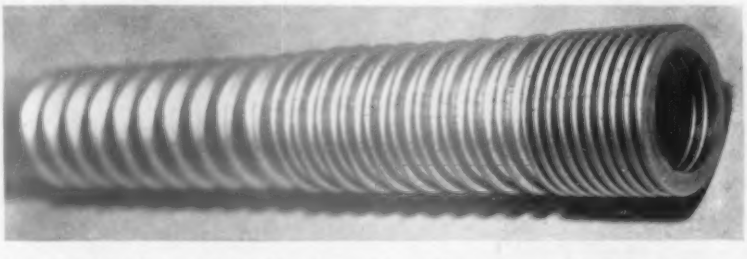
Resistance Welding of Thin Gauge Stainless Steel Tubing

★ The work-hardening properties of stainless steel are pretty well known. This characteristic of the familiar 18-8 alloy is an important asset in certain industrial fabricating applications, notably railroad equipment, highway trailers, etc. Higher physical properties are obtained and weight of equipment is reduced.

Steel producers have found it difficult to draw thin gauge stainless tubing because of the work-hardening characteristics of this alloy. Hence, such tubing has not been commercially available. Finding a need for thin gauge stainless tubing, Chicago Metal Hose Corp., 1315 S. Third Ave., Maywood, Ill., solved the problem by means of electric resistance welding. This company manufactures corrugated bellows and needs very thin wall stainless tubing for its fabrication. Rolled stainless strip in thicknesses of .003 to .006 in. is commercially available at reasonable cost. This strip is then fed into a continuous tube forming machine developed by Chicago Metal Hose Corp. The last step in this forming operation is a lap welded seam made automatically by a special resistance welding set-up.

Owing to the thin gauge not much power is required, the transformer being rated at 10 kva. Current is about 20 amp. in the primary. Special electrodes of Mallory 3 and Mallory 100 alloy are incorporated in the resistance welder for the seam welding job. An important feature of this welding is the rapid withdrawal of heat from the weld zone so that carbide precipitation does not take place. A continuous quench spray is employed to draw out the heat quickly. This makes it possible to use standard 18-8 stainless of .08 to .10 carbon without any stabilizing elements.

With this specially developed equipment, Chicago Metal Hose Corp. is commecially producing stainless steel welded tubing in sizes ⅜ in. I.D. to 2 in. I.D. The seam averages 23 over-



Seam welded stainless steel tubing is used in making corrugated bellows. There are 23 overlapping spots per inch.

The manufacture of stainless steel bellows stresses the metal beyond elastic limit. Consequently the welded seam must have high ductility.

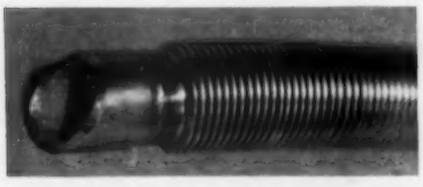
Dramatic test of strength of seam welded joint between two thin sheets of stainless steel. This alloy is so ductile that hydrostatic pressure blew the welded sheets into this "pillow" shape.

lapping spots per in. Wall thicknesses range from .003 to .006 in. As stated previously, the principal commercial application is in the manufacture of corrugated bellows for various industrial applications such as expansion units, valve seals, pressure regulators, flow meters and thermostats. The product can also be used as an extra-flexible hose for conveying liquids and gases under pressure.

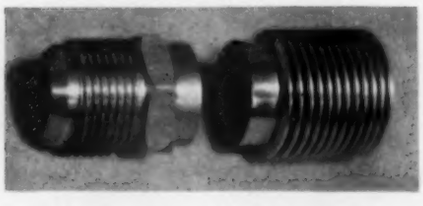
The corrugations in the tubing are obtained by a combination of pressing and spinning. The metal is spun inwardly and outwardly from the mean tube diameter. By working progressively from one set of spinning rolls to another, the operator produces the desired convolutions in the tubing. All of this mechanical working of the tubing stresses the metal beyond the elastic limit and it is important that the welded seam possess high ductility. All of the tests which have been made indicate that the welded seam possesses ductility as high or higher than the strip steel. Numerous vacuum tests on completed bellows indicate that the welded seam is 100 per cent vacuum tight. Metallographic examinations have been made to determine the micro-structure of the resistance welded seam. These tests indicate complete fusion.

Wherever corrugated tubing is used for a flexible hose connection under pressure, it is necessary to maintain a perfect seal at the coupling joint. This is now being done by means of resistance seam welding, eliminating the human element entirely. It is possible to weld metals of dissimilar composition and also of dissimilar thicknesses with complete success. In many applications a stainless steel coupling is welded at both ends of the hose to provide optimum corrosion resistance. The resistance welded joint is much quicker to make than any other type of joint.

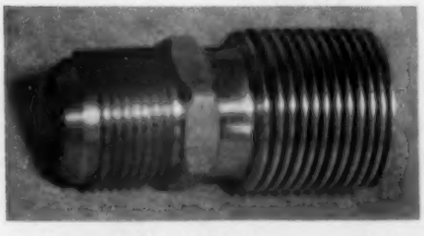
In making this circumferential joint, the coupling member is machined to make a snug fit inside the extended tubular end of the bellows (or hose). One copper alloy electrode is inserted inside of the coupling and the other (a wheel) makes contact on the outside of the joint. A water spray is played upon the joint, both inside and outside, to chill the weld rapidly and to keep the electrodes cool. This same welding operation is also employed in applying end seals on bellows.



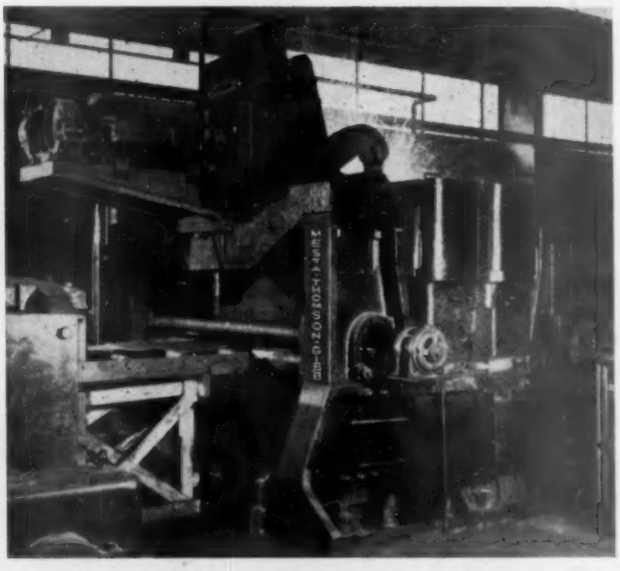
Resistance seam welding makes a pressure-tight seal at the coupling joint of a flexible hose connection.



Coupling member is machined to make a snug fit inside of extended tubular end.



Two members (shown above) assembled and ready for the resistance seam welding operation.



A strip steel butt welder installed in the pickling line at Jones & Laughlin cold rolling mill in Pittsburgh, Pa. This machine joins the coil ends quickly and permanently so that the welded joint will stand as much tension or bending as the rest of the strip. Steel mills are no longer forced to limit length of coils to amount that can be rolled from a single billet. Coil lengths are limited only by the customer's storage facilities and handling equipment.

Fig. 1—Arc welded steel railway trestle over St. Lucie River, Stuart, Fla. Built by Florida East Coast Ry.

Florida East Coast Railway Builds First Arc

Welded Steel Railway Trestle

By T. H. GARDNER*

Structural Engineer, Florida East Coast Ry., St. Augustine, Fla.

Fig. 2 — Close-up of three-span continuous girder construction.

THE FLORIDA East Coast Railway has fabricated an all-steel welded railway trestle for main line use. This structure is believed to be the first of its kind in use, and is unique not only for this reason but also because of the method of fabrication by railway forces. An all-welded temporary fabricating shed and plant was built solely for the construction of this bridge. This work was also done by railway forces. Preceding this work, the railroad had built and used successfully all-welded steel railway spans, both fixed and movable, for main line service.

The Florida East Coast main tracks cross the St. Lucie River on a bridge at Stuart, Fla., a famous fishing resort. Since 1925 considerable study has been given to tentative designs for approaches to the double-track bascule bridge. It was considered that a more economical type of permanent construction could be developed than the design originally contemplated.

After study of various combinations, it developed that an arc welded steel trestle was the most economical type of permanent construction. This design was predicated on single-track operation for the present, with possible future double track.

Design Features

The design adopted after considerable study and investigation, comprised the use of alternate continuous and simple spans carried on bents of 4 piles each. A shallow, short simple span was used at both ends. This was to reduce the depth of the span and the attendant reduction in height of back wall. The south approach is approximately 800 ft. long and the north approach is approximately 400 ft. in length.

Continuous Spans

The spans developed were three-span continuous, with bent spacing of 23 ft. 6 in., 30 ft. and 23 ft. 6 in. This ratio provided approximately the least maximum bending moment, with a fair proportion of bent reactions. The reaction on the interior bents was approximately one-third more than on the end bents. The bent spacings at the simple span which alternates with the continuous beams were 28 ft. The ends of the three-span continuous girders have a supporting bracket which cantilevers out 1 ft. 3 in. beyond the bents. This cantilever bracket carries the reaction of the simple spans. This reduces the effective length of the simple span from 28 ft. to 25 ft. 6 in. The design loading is Cooper's E 60. One ply 36 in. wide flange beams (160-lb.) were used for the continuous girders. The same section was used for the simple span, but cover plates part length were required top and bottom.

In the three-span continuous girder, any lateral movement in a bent is carried through the horizontal truss of the lateral bracing to adjacent bents. Each bent is designed to carry the assumed

*A digest of one of the prize-winning papers in the $200,000 James F. Lincoln Arc Welding Foundation Award Program.

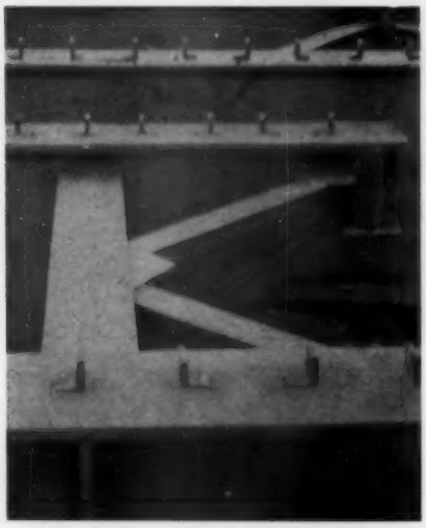


Fig. 3—From end cross frames in the simple span to the end stiffener, two lateral tees were used, forming a "K" frame.

concentrated lateral load. This design therefore provides a higher factor of safety, and provides a structure much more rigid in service. The piles are driven with a safety factor of 6. It is therefore highly improbable that there will be any progressive settlement of the piles.

Instead of the conventional built-up cross frames, we used 21 in., 59-lb. wide flange beams. These were squared off at the ends, and connected directly to the webs of the 36 in. beams. The intermediate cross frames were 10 in., 49-lb. wide-flange beams with a bracket of the same section stiffening the bottom chord.

Four-inch and 5-in. tees, split from 8-in. and 10-in. standard beams were used for the laterals. Both the flange and stem of the laterals were tapered off at the ends reducing the section to practically a point. This avoided the high stress concentration encountered with a square end section.

Simple Spans

The simple spans are shallowed up at the ends by removing a section of the web, bending up the bottom flange and welding to the web. The web is reinforced in the shallow part by side plates welded on either side. This design involved additional fabrication costs on the simple spans, but brought about the following advantages: (a) It reduced the effective length of the span 9% with some reduction in weight. (b) It avoided use of two sets of pedestals on the end bents with an attendant saving and reduced the eccentric loading which would have been imposed. (c) It allowed ease of correction in length of the simple spans in the field to take care of any inaccuracy in driving the piles. The ends of these spans have two sets of stiffeners either of which may carry the load. (d) It provided accessible details which can easily be maintained and inspected.

From the end cross frames in the simple span to the end stiffener, two lateral tees were applied forming a "K" frame. This avoided having two cross frames in adjacent spans. A bridge tie over the "K" frame, near the bent, was made with a removable section, enabling access through the deck down to the cap.

Anchor Bolts Omitted

The continuous girders are held down by large washers secured by bolts. The lateral movement is restrained by stops on the pedestals. The horizontal anchorage was effected by field welding triangular-shaped stop plates to the undersides of the girders. The simple spans were connected to the continuous girders by a connecting plate welded on the top flange of the adjacent ends of the girders. Where expansion is provided for, the alternate ends have this connection plate restrained from lateral movement by welding on the guide bars on one girder on either side of the connecting plate.

Fig. 5—The all-welded fabricating shed in process of erection.

Instead of the usual guard timbers, pairs of short angles with their toes pointed together are welded on the top flange. The bridge ties have a narrow slot to clear the horizontal legs of the angles. In this manner the ties are held from movement in either direction. Inner guard rails are installed.

It developed after much study and investigation, that a four-pile bent with all piles battered and the inner section of the projecting center line of the piles at different elevations, provided for the greatest rigidity with the least loading.

The cap consists of two 18 in., 58-lb. channels with the backs welded to the flanges of the piles and a cover plate on the top. About 3 ft. above the water line, a transom beam of two 10-in. channels is welded on the bent similarly to the cap.

The body of the pedestal is made from 14 in. pile cut offs, using a length of pile 7 in. on one flange and 19 in. on the other. The top of the pedestal, or the 7 in. section, is then extended out 5 in. on either side with plates, making the top of the pedestal 7 in. by 24 in.

(Concluding section of Mr. Gardner's paper will be published next month.)

Fig. 4—Details of four-pile steel bents which support the welded girders. These bents have 6 times the load-carrying capacity they are designed to handle.

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THE IMPERIAL IRRIGATION DISTRICT, El Centro, Calif., has awarded contract to the Pacific Iron & Steel Co., Los Angeles, for the construction of a welded structural steel extension to the power house structure at Brawley, Calif.

The "J. W. Van Dyke" at her dock after launching—This is one of the world's largest welded oil tankers —Photo. courtesy of The Atlantic Refining Co.

Problems of procedure control—

Welding in Shipbuilding

★ Welder's qualification tests do not always assure quality work—Common errors of welding technique pointed out—Danger of forced production

By FLOYD R. GORMAN*

ELECTRIC WELDING DESIGN and practice, though it has progressed considerably in the last few years, is still in the formative stage as far as standardization of the various codes, and procedures is concerned. It is true that in special cases the designing engineers and welding societies have collaborated with welding engineers and government departments in an effort to standardize various practices, but aside from these special cases, the various procedures in use at different shipbuilding yards have the effect of confusing the minds of the lesser-trained welders and supervisors as to the value of one procedure over another, causing them to lose sight of certain fundamental principles.

Standardization of welding procedures and practices is desirable from the standpoint of the designer, the draftsman, the assembly-man and the welder in the shop or field. But standardization should not be carried to the extent of hampering progress. Efforts to train the welder and welding supervisor to understand the basic principles have been neglected to the point where there is a shortage of competent welders and supervisors to carry on the work in accordance with the best established methods. Definite procedures and sequences have proven their worth in ship construction, but the details have become so numerous that it is almost impossible for the supervisor to direct each man under his charge in order that no important principle will be violated.

It appears necessary that the welder be trained to understand the principles involved in order that he may bear his share of the responsibility for correct workmanship. When one considers the compensation paid to welders in comparison to that paid to other crafts and considers their length of apprenticeship, together with the importance of their work in relation to the safety of the vessel as a whole, one can readily see that the welders enjoy the confidence of the designer, the draftsman, the engineer and the manufacturer, without having proved their character, dependability, or mental ability to understand the various factors affecting the quality of welds. Improper supervision and lack of moral responsibility on the part of the average welder are the causes of most of the trouble with welding. To assume that the average welder is capable of intelligently interpreting welding procedures and morally responsible to follow the best established procedure is a common error and must be corrected.

With the development of high-strength steels and the increased use of welding, metallurgists have placed too much reliance on the properties of

*Mr. Gorman is a U. S. Navy welding inspector on ship construction.

specimens welded by experts in the laboratory but have given scant consideration to the fact that ship conditions present many variables. Metallurgical reactions take place due to paint, dirt, atmospheric conditions and the sometimes awkward positions encountered by the welder. Many detailed procedures are specified but too frequently the results experienced are not the result of specified procedure, but the result of the most convenient procedure used by the welder doing the work.

The ultimate strengths of properly deposited weld metal and of the parent material are well known, but due to the unpredictable results obtained in the past, the designing engineers have attempted to compensate for possible errors by adding a safety factor. This high safety factor adds to the weld metal applied which increases the cost, weight, residual stress, warping, buckling and in some cases may have caused failure because of too much weld metal.

Fatigue Strength of Welds

In recent years a great deal of attention has been given to the behavior of welded joints under alternating stresses. The requirements with respect to preparation and shape of welds destined to carry static or alternating loads are frequently widely different and in some cases this weld metal added as a safety factor, becomes a decided factor in reducing the fatigue strength. For static loading the ultimate strength is roughly proportional to the cross-sectional area of the weld throat whatever its shape. But for alternating or pulsing loads, which the operation of a ship imposes on the welds, the soundness of the weld, shape and surface contour determine the fatigue strength. It may be seen from the foregoing that, if we are to reduce the defects resulting from improper supervision and faulty technique of the welder and hope to predict accurately the final results or strength of a joint, the system of selecting supervisors, student welders and qualifying hired welders should be changed to provide proper training and an examination to determine their mental fitness to understand the importance of welding procedures and sequences as well as ability to weld.

Under the prevailing system of selecting student welders in the past, any worker who expressed a desire to learn welding was permitted to register and the applicant at the top of the list (regardless of his mental or mechanical ability) was given a short period of instruction in the manipulation of the electrode. Many of the welders acquired some ability to weld by practice outside of a regular assignment or instruction and are working today with little or no understanding of the basic requirements of fusion welding. Some welding instructors have prepared a book of instructions in which various welding terms are explained and a few general principles are given, but little effort is made to determine the extent of study the student has given these instructions and as soon as he completes a certain number of hours of practice and can run satisfactory looking bead welds in the various positions he is permitted to try his luck in passing a welder's qualification test. Every effort is made to guide him in making this test, including practice on similar plates prior to the actual test. The previous practice probably accounts for the high average of successful test plates welded by students over those welded by the ordinary applicant for work who is not permitted to practice.

Many students who fail to gain rapid promotion in one establishment resign to apply elsewhere for a position as a qualified welder and too frequently obtain it simply by passing the test plate requirements. Previous experience is seldom given consideration, except to establish a rate of pay and it is not unusual to find the first-class welder and the student working side by side on the same class of work. If the work of the student is equally as acceptable as that of the first-class man there should be no wage rate differential. This condition is further aggravated by the fact that many third-class welders can turn out work, the quality of which is superior to that of the first-class man, assuming test procedure is not faulty. Due to this error in rate classification many of the lesser paid welders feel justified in turning out work the quality of which is proportional to their pay. Welders should be rated according to ability, general aptitude to follow instructions and understanding of procedure, sequence and knowledge of the various factors affecting the quality of welds.

There are a number of principles of procedure, sequence and welding errors which every qualified welder should be familiar with, particularly the following errors of technique:

What to Avoid

1. Too low current, (a) lack of fusion, (b) slag inclusions (chill effect), (c) porosity (chill effect), (d) undesirable contour.
2. Too high current, (a) undercutting, (b) porosity, due to excessive gassing, (c) low deposition efficiency, due to spatter loss.
3. Too short an arc, (a) danger of frequent sticking of electrode to work, each stick means unfused metal, (b) danger of dipping end of electrode into molten metal of crater breaking off projection of coating resulting in slag inclusions, (c) too high melting rate of electrode, (d) uneven fusion.
4. Too long an arc, (a) undercutting, (b) porosity, (c) spatter loss.
5. Excessive whipping of the electrode, (a) wasting of heat, (b) semi-fluid puddle, (c) minimum penetration, (d) coarse ripples with slag inclusions, (e) porosity caused by puddle solidifying before all the gases have escaped.
6. Excessive weaving, (a) enlarged puddle concentrating too much heat in local areas, (b) coarse granular structure of weld metal, (c) low tensile strength, (d) warping, buckling.
7. Segregation of beads, (a) porosity, (b) slag inclusions, (c) low tensile strength because of lack of complete fusion at bottom of bead separations.
8. Downward welding of vertical work, (a) minimum penetration, (b) porosity, slag inclusions, (c) concavity.
9. Single-pass welding of butts and fillets greater than ¼ in. in size, (a) rolled welds on flat fillets, (b) poor penetration at root of butts, (c) undercutting and danger of weld metal slopping over ahead of crater.
10. Continuous welds greater than one foot without back-stepping or wandering, (a) warping and buckling, (b) pulling of structure out of alignment ahead of finish welding, (c) maximum shrinkage.
11. Use of electrodes greater in size than 5/32 in. for vertical or overhead work, (a) high crowned beads making deposition of subsequent beads or layers difficult and the inevitable forming of slag pockets, (b) undercutting.
12. The use of a filler rod or other metal not actually deposited by the electrode, (a) contamination of weld metal, (b) low quality, (c) difference between structure of weld metal and added metal.
13. Failure to tie into other welds for water-tightness, (a) porosity leaks, (b) frequent caulked areas.
14. Failure to clean slag before deposition of subsequent beads or layers, (a) slag entrapment, (b) low tensile strength because the refractory substance of the slag has a higher melting point than deposited metal and does not float to the surface.

Some authorities may claim that a majority of the responsibilities for cor-

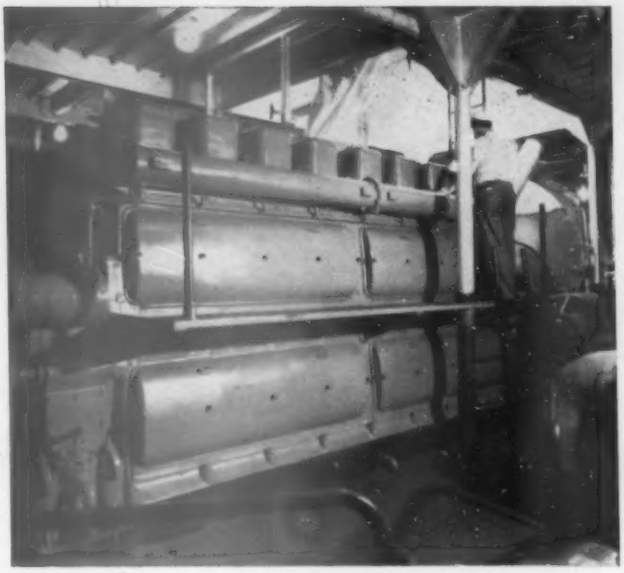
rect workmanship are problems and responsibilities of supervision. This is partly true. However, one well known authority on welding recently said, "We need more competent welding supervision but in casting about for welders capable of assuming these duties, we failed to find welders with sufficient qualifications. Even though we feel the need for better supervision, we do not feel inclined to fill this position just for the sake of filling it; and until such time as the welders show themselves capable of taking over these responsibilities, they will remain where they are."

With the ever advancing scope of welding and the scramble for manpower to carry on the work in an organized manner, comes the very pertinent question of where are the welders going to get their training? Various periodicals publish theoretical and practical information, but for some reason many of these articles are clothed in the language of the technical graduate and do little good to the men who need it most; namely, the welder and the welding supervisor.

More Complete Training

The relationship of welding to the various metal trades presents certain obstacles preventing its classification as a separate trade with definite apprenticeships. However, welding is an art requiring certain mental and physical qualifications which class it among the skilled occupations which require instruction and considerable practice for the acquisition of skill and dependability. The need for more complete training is obvious but agreement as to details, length and character of training has been neglected, principally because the demand for competent welders has exceeded the supply, forcing many establishments to break in new men to handle the peak loads. The result of this hasty and insufficient training is to cause considerable confusion and delay in meeting construction schedules as well as to raise the cost of welding through spoiled and inferior work which has to be rejected.

Some relief may be found by instituting an educational program and a more careful selection of student welders, particularly as to age and education. It has been found by experience that students between the ages of 20 and 26 years develop into good welders with a minimum of instruction and are able to grasp the reasons behind certain procedures more readily than older or younger students. The schools should be maintained on a part-time basis during the slack periods in order to train new students, as well as to provide the facilities for advancing knowledge and skill of the older welders. The benefits of recent research work should be passed on to the supervisory force, after the information has been broken down to its simplest form for transmission to the welders. Relief supervisors should be trained and made ready for the peak loads.



One of the twin 750-hp. diesel engines on the new 4000-ton welded tanker "Dolomite IV"—Photo. courtesy of International Nickel Co.

Analyzing the field of welding supervision, we find many untrained men in charge of important phases of the work with only one thought in mind —maximum production. It would not be fair to criticise these men too severely, because many of them have never had the training, or the advanced information necessary to supervise properly the work of welders. Not being welders themselves, they do not understand the requirements for quantity production, or the conditions affecting the welder and his ability to produce.

Production Limits

High production standards are desirable for a number of reasons, but many authorities have overlooked, or are indifferent to the fact, that in production welding with a given current and electrode size, the electrode will deposit so much metal per rod per unit of time; and for a given size of weld it takes a definite amount of time to weld a given distance. If a greater quantity, or distance is desired for a given time, all other things being equal, we can accomplish it in four ways:

(1) Increase the current.
(2) Use larger electrodes.
(3) Increase the time welder actually welds.
(4) Reduce size of the weld.

Increasing the current increases the loss from spatter and is also off-set by the limited number of welders who can handle high current values in ordinary production work. As a result this is not as desirable as increasing the electrode size. Even in this case there are but a limited number of welders who can handle large electrodes and overcome the difficulties of positioning the work aboard ship. Increasing the time the welder actually welds is difficult on account of fatigue. Finally we have the tendency to spread the metal thinner, skipping of difficult positions, neglecting to tie into other welds for water-tightness, cutting down the edges of plate laps or butt straps, slugging of welds, bridging of butts and numerous other sharp practices which are the most productive for the welder and the most frequently resorted to by him if pressed too much for quantity production.

The habit of supervisors in cracking the whip over welders for quantity production, without proper understanding of the requirements, results in nothing more than a small amount of increased production at a great sacrifice of quality, increased costs and a generally unruly body of welders. "Whip-crackers" have no business supervising welders because their ability to control the arc is dependent upon calm nerves, freedom from excitement and pleasant working conditions.

Ship foremen would do well to abandon the idea that welding is a cure-all for the errors made in fitting and strive to fit up as close as possible, thereby reducing the amount of weld metal required to make the joint. Particular care should be taken to keep the obstructions to a minimum. Ribbans, bolts, clips, strong-backs and all other assembly devices should be kept clear of the weld position for easy accessibility. Bad conditions or lack of preparation for welding react unfavorably on the welder's mental attitude causing him to lose interest in quality. He feels that the "buck" has been passed to him and promptly passes it along with inferior welds, unless kept under constant supervision. He has developed many bad habits by being left to his own resources in overcoming such difficulties.

It should be borne in mind that a ship's hull is probably the most intricate and one of the largest types of structures to be assembled without annealing. Hence the quality of workmanship, particularly the welding, should be of the highest order. The welder is in direct control of the arc and the quality of welds is wholly dependent upon the preparation, equipment, filler rod, welder's skill, pride and knowledge of good welding practice, plus competent supervision and inspection. Most welders would react enthusiastically to an opportunity to improve their knowledge of today's welding requirements.

There is no way of being certain of the quality of a weld by visual inspection. However, an experienced welder may, with fair accuracy, gain an idea of the quality by carefully noting the shape of the ripples, contour of the beads, position of the weld, whether open, obstructed, flat, vertical or overhead. Then, by recounting carefully his own experiences with such positions and the difficulties encountered, he can judge whether or not certain defects are likely to exist. It is for this reason that only the most competent welders should be selected to judge the quality of welds by visual inspection alone.

Many of the welders of today are the supervisors of tomorrow and unless an acute shortage of competent supervisors is to be avoided in the near future, the shipyards most vitally affected should begin now to develop welders with qualifications for supervisory and inspection jobs.

Fig. 1—Welded reaction chamber for refinery cracking process. Carbon-molybdenum steel was used for "creep" strength.

Welded Carbon-Molybdenum Steel Oil Refinery Pressure Vessel

★ Oil refinery operators are using carbon-molybdenum steel as a material for certain types of pressure vessels such as reaction chambers for cracking processes. Operating temperatures do not exceed 1000 to 1050 deg. F. The interest in this steel is based on several of its qualities, namely, its creep strength and elevated temperature properties, its ready weldability and the fact that it makes the vessels comparatively inexpensive.

Two reaction chambers built by The Babcock & Wilcox Co., Barberton, Ohio, for the Standard Oil Co. of California afford an excellent example of welded carbon-molybdenum steel construction. The case is interesting, not only because the vessels were the first of their kind to be built, but also because of the data accumulated during their construction.

The vessels are designed for operation at about 920 deg. F., at a pressure of 350 p.s.i. Each vessel has an outside diameter of 8 ft. and an overall length of 50 ft., the weight being 118,000 lbs. The bodies, heads and cover plates are fabricated from carbon-molybdenum steel plate 1-13/16 in. thick. The stud bolts used in construction are of chromium-molybdenum (SAE 4140) steel.

Figure 1 gives some idea of the welded construction. The bodies or shells, consist of five rings, or courses, made from plate formed into a ring, and welded. The five courses are butt welded together to form the body. The heads are formed from a single plate, and welded to the end courses. All body welds were ground flush with the parent metal on both the inside and outside surfaces. The manways, nozzles and reinforcement pads are forgings welded to the shells.

As there is greater allowable stress

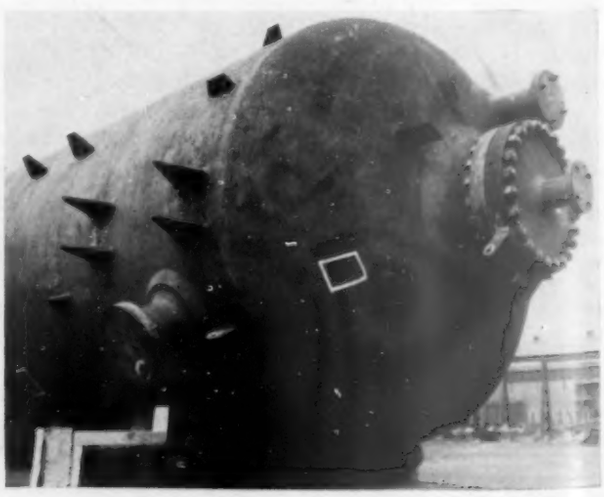


Fig. 2 — This welded reaction chamber was fabricated from 1-3/16 in. thick "carbon-moly" steel plate. If carbon steel had been used, plate thickness would have been 3-1/32 in. Hence weight saving was 40%.

for carbon-molybdenum plate than for carbon steel at 920 deg. F., it was possible to reduce the plate thickness from 3-1/32 in. to 1-13/16 in. Thus the total weight of the vessels was reduced about 40%.

In spite of the fact that the plates for the 10 courses came from different heats, their structure and physical properties were quite uniform. All welding on the shells was done with carbon-molybdenum electrodes. This includes the longitudinal welds on the individual courses, the circumferential welds fastening the courses and heads together, and welding the pads and brackets to the shells. A careful stress relieving program was followed after welding.

To begin with in both cases the longitudinal weld on each course was stress relieved at 1200 deg. F. before any of the circumferential welds joining the courses together were made. After all welding, including that of the pads and brackets, was completed, the entire vessel was given a stress relieving treatment. This consisted of putting it into a cold furnace, bringing the temperature up to 1200 deg. F. over a period of 6 hours, holding it at temperature for 2¼ hours, and bringing it down to 400 deg. F. over a period of 13 hours.

Considerable valuable information was also obtained concerning the properties of the welds, and weld metal. In order to determine the former, two weld test plates were made for each vessel. The plates were attached to the longitudinal seams of courses No. 1 and 5 of each vessel, and were welded at the same time and in the same manner as the longitudinal welds. After welding they were given the same stress relieving treatment.

Tests of a specimen made up of weld metal, and machined to 0.505 in. diameter showed the following physical properties after stress relieving for 2 hrs. at 1200 deg. F.

Tensile strength, p.s.i.	71,750
Yield point, p.s.i.	59,000
Elongation in 2 in. %	26.0
Reduction of area %	57.8
Fracture	¼ Cup

The vessels were also subjected to a series of physical tests to determine their soundness. These tests consisted of a magnaflux test of all welded joints, both before and after stress relieving, an etch test of all welds, on both inside and outside surfaces, and X-ray test of all welds, and a hydrostatic test of the completed vessels.

High-Pressure Pipe Welder Must Meet Strict Technical Standards

By R. W. BRECKENRIDGE*

★ High-pressure pipe welding is a type not found so commonly in job shops as are many other types of welding. Just how high are some of these pressures and temperatures? On steam power plant installations, temperatures run up to within 100 deg. F. of what might be described as red hot, not a bright red observed in strong light, but a very dull red observed in the dark. Pressures may run up as high as the pressure in an oxygen cylinder when it is first received.

Suppose that you are visiting a plant under construction. Welds are seen everywhere. Maybe business in your job shop is not so prosperous as you might desire it to be and suppose you resolve to apply for a job here. The question then is, "What are you up against in landing the job and swinging it?"

First, the superintendent of construction may ask how much experience you have had. Your reply may be, "Five years in a job shop." It must be admitted that much broad experience can be accumulated in that length of time. But high-pressure pipe welding is an exacting job and definite tests are required of the welders.

Standardized tests have been worked out by the American Welding Society and these have been quite widely adopted. For pipe welders they consist, briefly, in welding a specimen of pipe not less than 6 in. nominal diameter in a horizontal position with freedom in rolling it around, another specimen in a fixed horizontal position and a third in a vertical fixed position. Test specimens are then taken from these pipe sections.

If your specimens pass these tests satisfactory the boss may tell you to report for work. Probably you will be on an 8 hr. day. That does not mean that you will be expected to weld continuously for two 4-hr. stretches. Anyone who has put on a pair of goggles or a welding helmet and tried it knows that such a procedure is physically impossible. You will actually weld about half of the time and then relax while your helper chips the slag from the weld and prepares it for the next pass.

A tremendous amount of welded pressure piping was installed in the new Southwest Sewage Treatment Works, of the Chicago Sanitary District at Stickney, Ill.

If you attempt to chip your own welds, the vibration of the chipping hammer seriously impairs your ability to hold a steady arc. After 8 hrs. has elapsed you cannot always throw down the implements of your trade and go home. Some welds are so large that when the heat is once up, the weld must be completed without any intermediate cooling.

The positions in which you will be required to work are doubtless of much concern to you. Power plants and refineries are usually constructed as buildings intended primarily to house piping systems. Consequently the pipes and fittings are not so diligently concealed in the walls and in inaccessible corners as is often the case in other types of buildings. Seldom will you find it necessary to swing from some dizzy height in a safety belt. Carpenters are usually provided

*Mechanical Engineering Dept., Iowa State College, Ames, Iowa. This is a digest of paper presented at the Iowa State Welding Conference, March 21-23, 1939.

to scaffold up to comfortable working levels. And yet awkward and uncomfortable positions cannot always be avoided by any means. Ceilings, beams, other pipes and walls often interfere.

As to the material with which you will work, most low pressure work makes use of plain low carbon steel or wrought iron. When the temperature rises to the red hot range, the strength drops off almost half. At the same time heavy pressures will be pushing on the inside of the pipe and stretching will take place. This stretch is known as "creeping." If the material in the pipe is alloyed with a small amount of molybdenum, its strength at these high temperatures is noticeably increased. Molybdenum is the name (not a trade name) of a metal resembling lead in appearance. It melts at about twice the temperature at which iron melts. Since ites name is a "tongue twister" to pronounce, it is usually nick-named "moly." Carbon-moly is the name applied to the particular steel that is coming into wide use for high-temperature and high-pressure work. This kind of steel is no more difficult to weld than plain carbon steel, since molybdenum is one of the few alloying materials that do not appreciably affect weldability. The welding rods are made from the same material.

The shape of groove at the butt joint may be either a 90 deg. for the thinner pipes, or a U groove for thicker ones. The latter shape reduces the width at the top of the weld and also the amount of weld metal. Consequently it is a more economical groove to fill. Slip rings are usually placed inside the joints to aid in lining up the work and to prevent "icicles" from forming on the inside. The rings are flush with the inside of the pipe. The end of the pipe is thickened to maintain full strength. One-eighth inch rod is used for the first one or two beads and 5/32 in. rod for all remaining beads. Sometimes 30 or more beads are required.

Accurate Line-Up Necessary

With all of this preparation, you would not yet be permitted to take up your equipment and go to work. Pipe welding in a job shop usually involves lining up the pipe "by eye," tacking it, and then laying on the metal. On these high-pressure jobs much more accuracy is necessary. Many of these pipes, valves and fittings are welded together in some distant city and the units shipped out to the plant where they are placed in position and then joined to the other parts of the system with field welds.

Endless grief would result if narrow limits of accuracy were not maintained. One-sixteenth inch is not an uncommon tolerance. In the building itself marks are often placed on the steel work and secondary measurements taken from them. As a welder you will not concern yourself much with this pipe fitting, but you must refrain from tacking or welding joints until you have the properly authorized "go ahead" signal.

Before actually beginning the weld there is still the matter of preheating to consider. If a joint is welded without preheating, the cold base metal has a mild quenching effect. This is not seriously objectionable, but a slightly more ductile material results if a preheat is used. A temperature of 425 deg. is considered to be suitable. The heat can be applied with a large welding torch, but this is uncomfortable and inconvenient to maintain while the weld is being made.

Induction heaters provide another possible source of heat. These devices consist of circular bands of aluminum which are hinged and can be opened and then closed, around a joint, forming a spiral coil through which a heavy and variable a-c. current can be passed. By induction, the joint is soon heated. These devices work well in places where straight pipes are being joined, but near elbows and heavy fittings they are often difficult to place. Another objection is the magnetic distrubance which seriously affects the welding arc. These heaters must be shut off while the welding is actually in progress.

Wrap-Around Coils

A more convenient source of heat is the wrap-around coil, a resistance coil from about 6 to 15 ft. long on which porcelain insulators are strung. The device resembles a large snake. One coil is wound around the pipe on either side of the joint and wrapped with asbestos blankets. The current is then turned on and soon the proper temperature is attained.

How are you to tell when the proper temperature has been reached? High temperatures are measured with thermocouples. When two wires made from different metals are twisted together at both ends and when one junction is heated while the other is kept cold a very weak current of electricity is generated. The current varies directly with the difference in temperatures between the two ends. If the current can be measured accurately, the scheme can be worked backwards and the temperature be thus determined.

Almost any combination of metals will act in this way, but the two most favorable alloys for this work are nickel-chromium and nickel-aluminum - manganese - silicon, known as chromel-alumel. A very delicate voltmeter is one of the instruments that may be used to measure the current. Often the instrument has an automatic switch connected with it that operates a larger switch which controls the heavy current flowing to the wrap-around coil. Thus the temperature at the joint being welded is automatically maintained.

At last you are ready to go to work. The construction boss and all of the company officials and future plant op-

Industrial piping installations employing high-chromium steel pipe can be fabricated by oxy-acetylene welding.

erators hope you will make a sound joint. If you fail, the result may be a major calamity. To assure the realization of their hopes, one or more testing or inspecting devices may be used. The finished joint may be x-rayed. From the resulting photograph, possible defects may be located, or better still, sound deposited metal may be shown. It is not possible to x-ray all of the joints on a job. Some of them will be inaccessible to the equipment that is needed for such photography.

Still another testing device that may be put onto your work is the arcronograph. In outward appearance it resembles one of the earlier radios. It is an electrical device that connects into the circuit leading to the electrode holder and records on a long strip of paper the fluctuations in voltage that occur. To anyone not familiar with arcronograms they appear to be a long series of irregular zigzag lines. But to one who matches the patterns that appear, with the good and bad practices followed by welders, he will be able to say when favorable welding conditions are prevailing. If your work is being recorded continuously and impersonally, your tendency will be to exercise skill with unabating attention. This device is not a positive and unfailing indicator of all possible defects, but it is a device that can be applied to the checking of field welds even in many difficult positions.

After you have finished applying the metal to the joint, there may be many stresses in the various parts due to the uneven heating and cooling. These stresses should be relieved. Otherwise they may add to the internal pressure that will later come on the pipe and the sum of the two forces may cause a failure. These stresses are relieved by placing a third wrap-around coil over the weld itself and by means of all three coils heating the joint and adjacent pipe up to about 1200 deg. F. which is definitely red hot. This temperature is maintained for one hour for each inch of pipe thickness. The temperature is then slowly lowered and the coils and thermocouples removed.

After you have finished all of the high-pressure and high-temperature joints on the installation, the system will probably be filled with water and a pressure applied which exceeds the usual working pressure. The inspector then takes a heavy machine hammer and strikes each joint three or four lusty blows while it is under pressure.

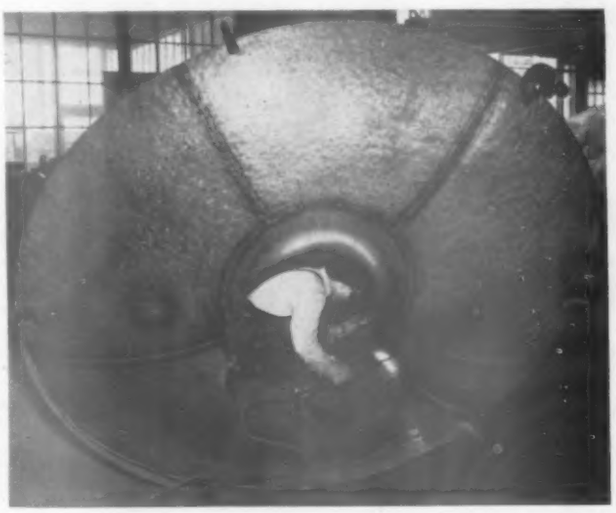
Welded Fabrication of a Nickel Brew Kettle Dome

★ The brewing industry is careful in selection of metals that contact their product during processing. Pure nickel, rust-proof and non-toxic, is suited for many brewing applications. Its strength, ductility, and ease of fabrication simplify and reduce the hand forming required for equipment such as the deep kettle dome illustrated.

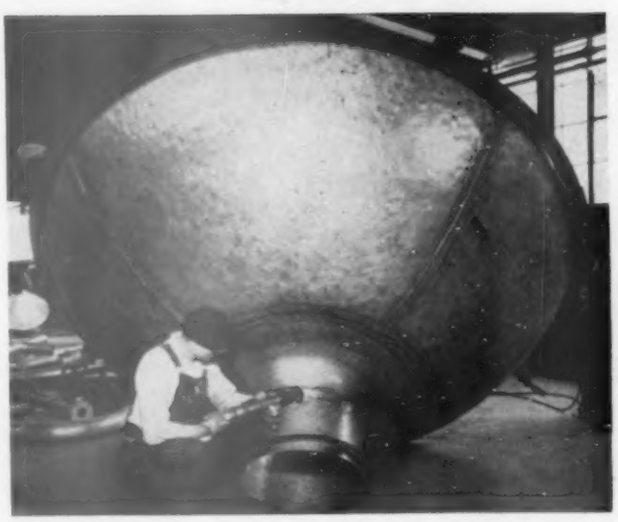
Four pieces of standard cold rolled, soft temper, "A" nickel sheet 60 in. x 97 in. x 0.125 in. were used to prepare the four orange peel sections of the dome. After rough forming, by hand, to curvature of both radii, the ends were trimmed for butt joining. The radial seams were tack welded and the dome began to take shape. The hole in the center of the dome was trimmed to take the circular throat section which had already been welded from two pieces: a hand bumped annular part joined to a 24 in. dia. cylinder 14 in. long.

All welding of the dome was accomplished using 3/32 in. No. 41 nickel gas welding rod and a slightly reducing oxy-acetylene flame. In accordance with standard practice no flux was employed.

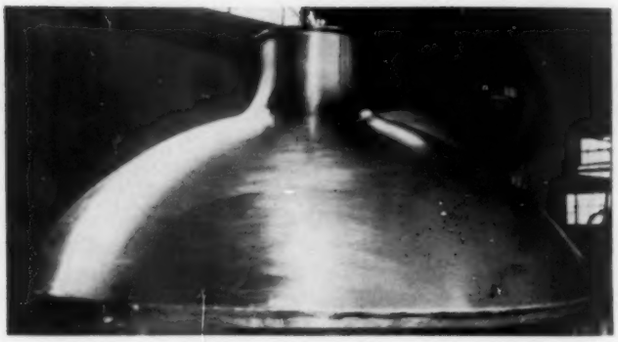
The annular part was welded to the formed and tack welded orange peel sections which were clamped to a



Welding the inside radial seams of the nickel brew kettle dome. The four sections were hand formed from .125 in. sheet.



Grinding outside welds of the dome. Note steel angle supporting ring around outer circumference.



Finished nickel dome after polishing. Has a 3 in. straight flange for fitting into an "over-boiling ring."

circular 3 in. x 3 in x 5/16 in. steel angle ring. The angle ring served as reinforcement to help maintain shape during handling and welding. The radial seams were first welded on the inside with a depth of penetration of 2/3 to 3/4 of the sheet thickness (0.125 in.). This was followed by welding outside. The purpose of welding from both sides was to provide a weld capable of being polished on the inside as well as the outside of the dome. In addition, this procedure minimized possibility of porosity that might interfere with subsequent polishing.

On completion of all welding, inside and outside welds were rough ground. Care was taken to leave a slight reinforcement in weld areas to permit cold working of the weld metal. The rough ground welds, projecting a little above the sheet surface, were hand hammered. Following this, the entire dome was planished with a spring hammer.

For polishing, standard nickel practice was adhered to, starting with a 120 grit wheel, followed by 180. A Tampico wheel was used for the final satin finish.

This job was built by Schock Gusmer & Co., Hoboken, N. J., and is installed on a nickel-clad steel brew kettle fabricated from 5/16 in. thick 10% clad plates. The brew kettle has a capacity of 160 barrels. The equipment is installed in the new brew house of the Sudbury Brewing and Malting Co., Sudbury, Ont.

Readers' Question Box

Welding Alloy Cast-Iron Cylinder Blocks

In our June, 1939, issue, page 31, we presented a welding problem submitted by A. F. Morton, one of our readers. He explained the difficulties he was encountering in attempting to make machineable welds in cylinder blocks of an alloy cast-iron, containing chromium and nickel. THE WELDING ENGINEER will pay $5.00 for replies accepted for publication in the "Readers' Question Box." Replies should not exceed 500 words.

» «

Recommends Oxy-Acetylene Welding with Cast-Iron Rod

By A. Q. ROBERTS

★ These alloy cast-iron cylinder blocks can be repaired with absolute satisfaction by the oxy-acetylene process, using the best grades of regular cast-iron rod and a good grade of cast-iron flux. Chip the crack as nearly through as possible and then preheat the block slowly and evenly to a good red heat. When welding is commenced, be sure to melt all the way through the crack, using extreme care not to leave any part of the base crack line undisturbed. If you do not melt all the way through and raise all the white line particles in the crack, pin holes will be sure to develop.

When you have melted through until the crack stays open at least ⅛ in., flux the weld thoroughly and hold the flame black, not allowing the blue cone to come in contact with the metal. Always use large enough tip so as to cut it down to a soft easy flame with little excess acetylene. Never allow an oxidizing flame as this will cause hard spots.

Fill in the crack evenly, working out all slag and laps. Keep the heat even at all times and work the added metal in evenly at the edges of the joint. Then there will be no hard spots. After welding is completed, heat the entire block to a red heat, holding it there for at least 15 min. This will anneal and relieve any strains set up by welding. Cover the block thoroughly to cool.

I have used this method during the past 10 yrs. and at one time welded 126 heads and blocks in 10 months, with the loss of but 2 castings. In all cases I have been able to machine and file all welds. I find that chromium and nickel in these jobs, while making the metal less easy to flow, will amalgamate when puddled in with the cast rod; nevertheless, it still remains one of the difficult jobs and not all welders will exercise the extreme care required.

Machineable Weld in a Cast-Iron Cylinder Head*

★ A cylinder head was broken between the valve ports, with the fracture extending through the edge of one of the valve seats. In order to obtain thorough penetration, it was first necessary to chip out the entire crack and bevel the surfaces by grinding a vee with a 90-deg. included angle until bright, shiny metal was reached. The elimination of dirt and surface oxides by grinding later insured complete fusion of the weld metal with the base metal when welding was started.

To prevent uneven heating which would set up severe strains in the casting, thorough preheating of the entire cylinder head was necessary. For this purpose, a temporary furnace was built around the casting. Bottom and sides consisted of double rows of firebrick with asbestos paper between. Small openings were left between the bricks of the lower tiers and holes were punched through the asbestos paper lining at these points. The purpose of these holes was to permit a sufficient amount of air to enter the furnace and insure proper combustion of charcoal which was used as fuel.

A covering for the furnace consisted of additional asbestos paper supported by several pieces of angle iron laid across the uppermost brick tier. Since this covering completely closed the top of the furnace and extended part of the way down the sides, small holes were punched in it to allow for escape of products of combustion.

Use 1400 Deg. Preheat

With everything in readiness for welding, the charcoal was lighted and the furnace was covered over. The entire casting was then slowly and evenly brought to a temperature of between 1,300 and 1,400 deg. F., and maintained at this point throughout the entire period of welding. To prevent harm to the casting, extreme care was taken to keep temperature at or below 1,400 deg. F.

Welding was carried on with a neutral flame through a small opening in the asbestos cover. Oxweld No. 9 cast-iron rod was used with Ferro flux. The blowpipe welding head was one size larger than ordinarily used for the same thickness of steel.

Stress Relieving

When welding had been completed, the opening in the asbestos cover was closed over and the entire casting was again brought to an even temperature of between 1,300 and 1,400 deg. F., again being careful not to exceed the 1,400-deg. limit. The casting was then held constantly at this temperature for a number of hours equal to the thickness in inches of its heavier section.

After this prolonged heating, the casting was allowed to cool slowly in the dying charcoal fire. The rate of cooling was so controlled, however, that full cooling to room temperature came well within the 6 to 12 hr. recommended.

Careful temperature control throughout the repair resulted in an excellent joint, with the casting itself entirely free from harmful stresses. No hard spots were found during the machining of the weld or valve seat.

*Condensed from "Oxy-Acetylene Tips," June, 1939, published by Linde Air Products Co.

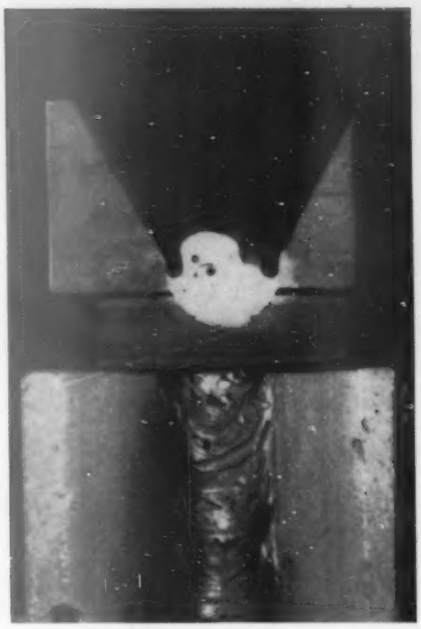


Fig. 1—A "horrible example of a first layer in a vertical vee butt joint. Note excessive height of bead and evidence of porosity.

Recommended technique for manual welding of vee

Butt-Joints in Steel Plate

★ Greatest difficulty is encountered in welding root of vee joint in vertical position — Advantages cited for using short and rapid transverse weave for root weld

By C. T. GAYLEY

THE MANUAL welding of vee butt joints in medium steel plate is one of the important jobs in the construction of tankers, merchant ships and men of war. Supervisors are always on the alert to see that no poor weld metal is buried in the bottom of the vees. The average welder seems to have most of his trouble in welding the root of the joint in the vertical position. The root of the overhead weld is second in this respect.

While the multiple-bead method of filling in a vee butt joint has been succeeded by the woven layer technique in nearly all shops, still the reason for a great deal of failure in properly welding the root of a vertical joint, seems to be in the persistence of the string bead technique for the root of the joint. The welder strikes the arc at the bottom of the joint and starts welding upward. When the molten metal bulges out a little by reason of gravity the arc is "whipped" upward along the backing strip to allow the molten metal to cool or solidify before it spills over or runs down. The arc is then brought back to the crater and the process repeated. This whipping action may be carried upward about an inch and a half to two inches and may be repeated about 30 times a minute.

Results typical of the above technique in the deposition of the first layer in a vertical vee butt joint in ¾ in. plate are shown in Fig. 1. The upper part of the figure shows a macrograph of the cross section of the layer, and underneath is shown the general appearance of the surface. The specimen selected is of course a *horrible* example and illustrates two errors in the deposition of this all-important first bead. The section selected is through an old crater, where one electrode had been consumed and the arc broken, and then with another electrode a new arc was struck in the cold crater. Note that the bead is especially high, and shows porosity. Advance from the crater was made before a molten pool had been formed with the second electrode. It had the same effect as the use of too little heat. The arc should have been struck at the side of the cold crater, brought into it and held until the normal pool of molten metal was formed, and then the welding continued.

The entire layer, or bead, shown in Fig. 1, has a highly convex surface due to the fact that the molten weld metal did not "wet" the edges of the plate and permit cohesion to pull it out toward the flat. Instead, gravity sagged it outward and downward with the resulting contour. Undercutting has

Fig. 2—How slag may become trapped in the undercut channels of the first bead, when second layer of weld metal is deposited.

occurred at the edges of the plate, which is just another way of saying that the molten metal did not "wet" and adhere to all the area eroded by the arc. These undercut channels are likely places for slag to be trapped when the next layer of metal is deposited.

That slag may actually be trapped in this manner is shown in Fig. 2. On etching the specimen, slag is revealed at the points where the channels beside the first bead were located. Had this joint been completed, a root bend specimen machined from it in the usual way, and bent with the root of the weld in tension, a crack would surely have started at these slag inclusions (points of weakness) and progressed through the weld metal.

A second reason why this type of weld would fail in a root-bend test is the presence of a very heavy second layer. Having deposited a first pass like that shown in Fig. 1, the welder would put in a heavy second layer, trying to penetrate the grooves between the slopes of the bevel on the edge of the plate and the high convex bead put down by the first pass. The result would be a heavy layer of coarse tree-like crystals in the weld metal (relatively brittle) and stresses localized by a slag inclusion might readily cause its failure.

A weld having defects similar to those described for Figs. 1 and 2 might cause a failure in butt welds in a ship, subject to alternate stresses, due to the natural roll of the ship.

If Figs. 1 and 2 are examples of welding the root of a vertical vee-joint with poor technique, then it follows that a technique by which the first and second passes could be deposited in thin, flat, or even concave layers, would be desirable. Cross-sections of samples prepared in this manner are shown in Figs. 3 and 4.

The root layer shown in Fig. 3 was put down with a short and rapid transverse weave coupled with a short "whip" up the backing strip after each four rapid and short traverses in the horizontal direction. In other words the path of the arc described an inverted T. The "whipping" should not be carried more than ½ in. above the crater, or as short as possible and still keep the weld metal in place. The transverse movement may be no more than 3/16 in. The path of the inverted T should be traversed at the rate of about 60 times a min.

This short transverse weave is important, since it is this motion that prevents surface tension and gravity from drawing the molten metal into a high convex bead. This motion takes the metal to the sides of the joint, wetting them and causing it to adhere, filling up where the arc had previously eroded the sides, and thus preventing undercut. The advance of the crater along the direction of welding should also be

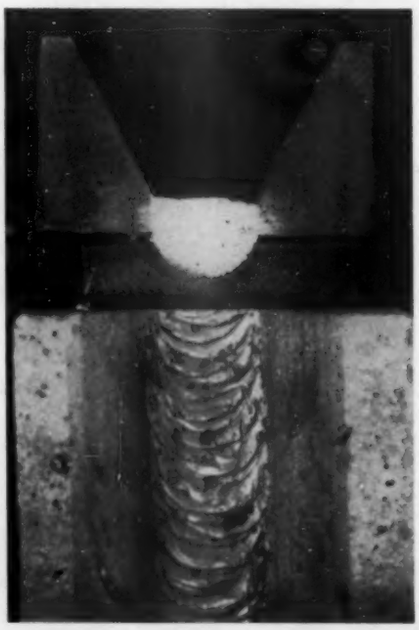


Fig. 3—A root layer deposited with short and rapid transverse weaves coupled with a short "whip" up the backing strip after every fourth traverse in the horizontal direction.

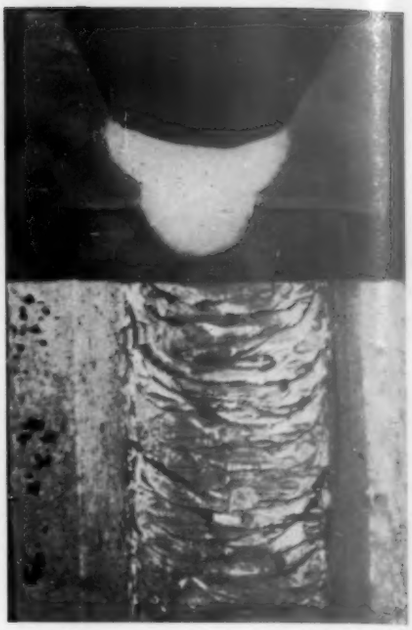


Fig. 4—This transverse technique spreads the edges of second layer out over edges of first layer, increasing width of deposit with each succeeding layer.

rather rapid, so that the final result is a relatively thin, flat layer in the root of the vee, as shown in Fig. 3.

Some brands of electrodes have characteristics that make it advisable not only to hesitate an instant at the side of the vee, but actually to pull the arc up the side of the bevel about ⅛ in. and then feed the arc down and across. These short movements require skill, especially since the traverses should be made at the rate of about 60 per min. When this technique is used, no whipping is done.

The second layer is put in with a fast transverse weave and no whipping. At the end of each transverse a brief pause is made to penetrate the edge of the plate. During the pause, the electrode is not advanced to maintain the normal arc length, but is allowed to melt away for an instant, thereby lengthening the arc, and eroding the side of the bevel a little distance upward, so that no undercut shoulder will be left.

The objects to be gained in putting down this layer in the manner described are: (1) Does not require whipping the arc, for this device, at its best, is accompanied with the danger of weld porosity, and slag entrapment; (2) Spreads the edges of the second layer out over the edges of the first, making it wider, as shown in Fig. 4. This still further insures no slag entrapment at the edges of the

(Continued on page 40)

Brief Sketches of Welding Jobs

Air compressor unit built from Model A Ford engine and mounted on an old automobile chassis.

Welding Converts a Ford Engine Into a Compressor

By J. C. COYLE

★A welding shop in Yuma, Ariz., is now building a light compressor for use in tree spraying, for operating a jack-hammer in prospecting, or as a praving breaker. The compressor is built from a Model A Ford engine, and is driven by a four-cylinder Chevrolet engine through the medium of two universal joints. The unit is mounted on an old automobile chassis, cut down somewhat. The two wheels make it easy to tow over country roads.

To cut down excessive vibration, when a gasoline engine is converted to an air compressor, the builder conceived the idea of cutting the 4-cylinder crankshaft in two and realigning the shaft by giving it a quarter turn. When welded together in the new alignment only one piston comes up to top of stroke at a time. This crankshaft alteration was handled by suspending the crankshaft in a lathe and making a vee cut nearly through in the middle of the center main bearing as it revolved. The shaft was then held with the tool rest while the remaining metal was cut through with a hack saw.

One end of the crankshaft was given a quarter turn, checked carefully for alignment, and then tack welded in place. The cut was then built up with a mild steel rod, using an oxy-acetylene torch, the shaft being rotated by hand while welding. To prevent warping the shaft was rotated at high speed until the weld was cool. It was then turned down at the main bearing to ⅛ in. undersize, and rebuilt with bronze. The lathe was run again till the work cooled and then the bronzed bearing was turned down to size and polished with a file.

With the old head and manifold removed, the head bolts were shortened to hold a ½ in. steel plate, on an asbestos gasket. Holes were drilled through the plate for 1½ in. intake valves, seating on the inside. Guides for the valves were welded into arches made from ⅜ in. by 1 in. bar, the ends of which were welded to the plate. Light valve springs were used, similar to those usually employed in grinding valves. They rest on top of the arches, held in place by a washer and metal pin.

The 1½ in. exhaust valves each seat on top of a disc of ¼ in. mild steel, turned down on the lathe to fit inside of a 3 in. section of 2 in. iron pipe and welded. These sections of pipe were pressed into holes in the head plate and welded all around. The top end of each pipe section was threaded to take a standard 2 in. pipe coupling, with a screw plug in the top end. Guides for the exhaust valves were welded into sections of ⅜ in. by 1 in. bar, and then welded inside the couplings. The valve springs rest on top of these bars. Valves may be inspected by removing the screw plug, or removed for cleaning by unscrewing the coupling .

The exhaust manifold, 1¼ in. by 22 in., was welded over opening cut with a torch in the side of the pipe sections which house the exhaust valves. It is capped at one end and the other is attached to branch pipes leading to the two air receiving tanks. These tanks were made from ¾ in. by 12 well casing, with welded heads of the same thickness, and strengthened by a tie bolt through the center of each tank and welded to the heads. The outer end of one tank was equipped with two short sections of 1½ in. pipe, joined by a coupling, into which a pressure guage was tapped. A pop-valve was fitted on the end of the outer pipe section. The other tank has a similar 1½ in. connection for the air hose.

The rear portion of the Chevrolet chassis was cut off, and the rear cross brace removed. The frame was closed somewhat and the motor supports were all welded into place. The chassis frame was bent inward at the front and a cross member and a trailer hitch welded on.

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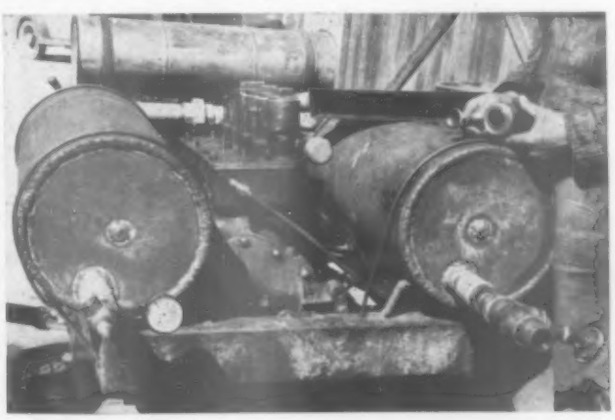


Rear view of air compressor unit with the man who built it holding an exhaust valve and housing

Welding a Gas "Shower Bath"

By HENRY W. YOUNG

★Ordinary illuminating gas can be "scrubbed" to advantage, especially if valuable by-products can be recovered from the bath. To do the work, however, a special kind of scrubber is required; a giant steel "shower bath," called a tower absorber. Figure 1 shows a tower absorber erected by the Portland Gas and Coke Co., Portland, Ore. Their chemical plant contains many buildings and equipment devoted to the recovery and processing of a large number of by-products incident to the production of gas from oil. This oil is itself a residium from cracking of petroleum in the manufacture of gasoline.

The tower takes care of the initial stages of recovery of two important by-products. One is benzol, which is used as a blend in making a motor fuel. The other, toluol, is used extensively as a solvent. This tower represents an investment of about $40,000. Sixty ft. high and 10 ft. in diameter, the tower was fabricated at the plant of King Bros., Portland, Ore. It was constructed in halves and these were transported to the site on trucks and erected with a gin pole rig.

The lower half of the tower, built in four sections, is of 5/16-in. steel. Around the top, a butt strap was welded, made of ⅜ by 6-in. steel. This was welded on in the shop, with a ¼ in. fillet weld all around, inside and out. A number of bolt holes were drilled in the butt strap and in the lower edge of the upper half. On the site, the upper half was lowered into the butt strap ring, the edges of the two halves not quite joining, the bolts were inserted and drawn up

Tower absorber of welded steel at plant of Portland Gas and Coke Co., Portland, Ore.

Welding the boottom of shell to the base plate.

the ends of the 7-in. I-beams, steel angles were welded to the interior of the shell at the proper levels. The I-beams, shop cut, are bolted to the angles, so as to be removable.

For the bottom of the tower, a ⅜ in. steel plate, 10 ft. 1¾ in. in diameter was flame cut and welded. A similar plate was constructed for a cover, the latter being reinforced with an I-beam on the underside.

To hold the bottom plate firmly in place on the concrete foundation, eight brackets were welded to the outer surface of the shell near the edge. Holes were then drilled in the brackets to receive bolts that had been embedded in the concrete. Total weight of tower, including grid supports, is approximately 29,000 lbs.

» «

Welded Barges Carry Equipment For Petroleum Drilling

★ In parts of the shallow in-shore and offshore waters of the marsh lined coast of Louisiana and East Texas, there will be found floating equipment used for oil drilling. When the petroleum industry first began to look for oil in the terrain overlaid by these shallow coastal waters, their problems involved the driving of piling and erection of stable platforms on which work could be performed and accommodations furnished for workers during periods of rest.

The oil industry then turned to a new method of drilling, in which the equipment is floated to the selected spot. Instead of a derrick resting on platforms set on piles, it is mounted on twin barges. This eliminates the initial construction phase and the derrick can be floated away intact when its function has been completed and the well has been brought in.

These barges are welded to secure designs of maximum strength. A recent barge built for one of the petroleum companies cost around $43,000 and the operating company paid a royalty of $15,000 for use of the design. The cost of the derrick and other equipment mounted on the barge added over $200,000 to the total investment involved. The oil industry considers the investment as worthwhile because it eliminates time consumed in driving piling and building a wooden derrick floor and pipe racks. In operation, the barge is floated to the desired location by a tug where, after being carefully positioned, it is ballasted with water and set on the bottom of the shallow stream or bay. After the drilling has been completed, the water ballast is pumped out and the barge moved to the next location, without dismantling the rig or tearing down the derrick.

While the barges are so solidly constructed that they can withstand severe gulf storms, it is possible, upon warning of the approach of a destructive hurricane, to remove the barge and equipment to a safer place. Figure 2 shows a welded drilling barge in course of construction at the plant of Pennsylvania Shipyards, Inc., Beaumont, Texas. This barge is built in two units each 120 ft. long, 24 ft. wide by 10 ft. deep and assembled with an 8-ft. gap between the units for the drill stem and pipe. The barge contains water and fuel compartments, a heavy steel structure to carry the derrick, the drill pipe and casing racks and the slush pumps. A mud pit is provided on each side. The heavy

tight, holding the two halves in position until field welded inside and out into one continuous cylinder.

Each of the four sections in the two halves was made of sheet steel, having one seam welded flat on the floor making a sheet 96 in. by 378 in. by 5/16 in. thick. The sheet was then rolled into a cylinder and welded. Adjoining sections were then welded in such position that the vertical seams were staggered to break the joints.

In operation, the tower contains wooden grids laid up in tiers from bottom to top. The gas enters through a 36-in. nozzle at the bottom, passes up through the grids and out through a 30-in. nozzle at the top. Meanwhile, petroleum enters through a smaller orifice at the top, is sprayed onto the grids and as it drips down through them washes the gas, taking up the toluol and benzol. The latter are then recovered from the petroleum wash.

The wooden grids inside are carried by four sets of grid supports consisting of two 7-in. I-beams extending across the tank, each pair carrying four 5-in. I-beams at right angles. The grids consist of 1-in. by 6-in. fir boards set on edge, and spaced 1 in. apart by blocks and held together in sections by bolts. These are then placed on the grid supports, one section above another at right angles until the space is filled. To carry

Fig. 1—Floating power plant for oil drilling. All equipment mounted on welded barge.

Fig. 2—One of the twin barges in course of construction.

superstructure connecting the two barges has a central removable panel to permit towing of each hull separately through narrow channels. The power plant used for drilling and the barge carrying it are shown in Fig. 1. The boiler barge measures 84 ft. by 28 ft. by 7 ft.

» «

Welded Drag Smooths Banks

By J. C. COYLE

★ A 10-in. square welded hollow beam, 20 ft. long, suspended from the front end of a dragline bucket by two chains, has proved

How the welded drag is attached to bucket.

to be an excellent device for smoothing the banks of a canal or roadway. This arrangement permits bucket to rest on the beam in dragging hard spots.

» «

Flame-Cut Steel Plate Flywheels Are Safer to Use

★ In recent years, machine designers in increasing numbers have specified use of rolled steel plates for flywheels. Steel plate flywheels can be operated safely at much higher peripheral speeds. In addition, the use of steel plate permits the designer to effect appreciable savings in flywheel weight, and eliminates pattern expense.

Lukens Steel Co., Coatesville, Pa., recently produced two steel plate flywheels, said to be the largest and heaviest ever made in steel plate. They are also said to be the largest and heaviest steel plates ever produced, and their manufacture required the casting of the largest and heaviest ingots ever produced by Lukens Steel Co.—110,000 lbs.

Each of these flame-cut steel plates, before machining, weighed 56,315 lbs, and measured 165¼ in. in diameter and 9⅛ in. in thickness with a shaft hole (29 in.) in the center. They were used by Mesta Machine Co. in the fabrication of flywheels for drives of a new hot strip mill in the Pittsburgh area.

After flame-cutting, the circular plates were smooth-machined on the inside diameter to a tolerance of plus 0, minus .005 in. and to the shaft hole size of 31.015 in. Other surfaces were rough machined to finished size.

» «

Worn Caterpillar Sprockets Rebuilt at Saving of 40%

★ Arc welding saves contractors 40% of the cost of replacing worn caterpillar parts such as sprockets and rails. Some specialists in this kind of repair work guarantee that rebuilt parts will last at least as long as new ones.

A high-carbon electrode was used to build up the "cups" of this sprocket. Photo (Hobart Bros. Co.).

A coated high-carbon electrode was used on this job. Greatest degree of abrasion occurs in the cup, which gets the direct pull of the sprocket. There is no severe wear on the sides, unless the sprocket happens to be rubbing against adjoining members.

» «

A Welder Tackles Big Shoe Job

By J. D. MUELLER

★ A Dallas, Tex., shoe repairer wanted a shoe—a big shoe—to advertise his service, and to help him deliver his work. He contacted Gene Frederick, of Dallas, a man who delights in doing what others say can't be done.

The shoe was built for use on a motorcycle sidecar, and conforms as nearly as possible to the pattern of a man's shoe. It is large enough to hold a man's suit on a clothes hanger. The finished job stands 42 in. high, is 5 ft. in length, and 2 ft. in width. The rear is equipped with a door, which is hinged and provided with a lock.

In construction, oxy-acetylene welding was employed chiefly because it required a great amount of hand shaping. In some places the welding was done before the shaping; in some parts it was done as part of the shaping; and at other times it followed the shaping operations. There seemed to be no end of cutting, twisting and hammering required.

Welded shoe for novel delivery advertising.

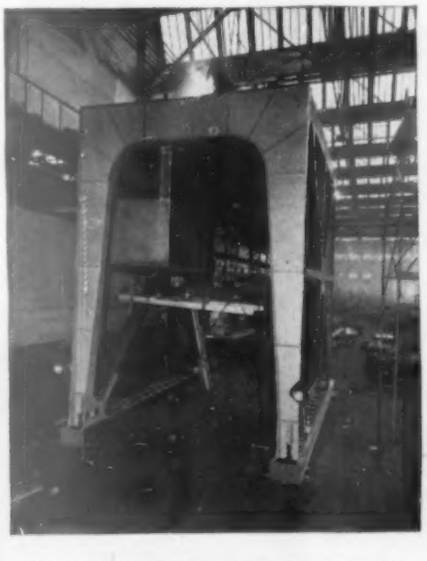
In constructing the metal shoe, Mr. Frederick started with a real shoe furnished by the customer as a pattern. Then he laid out a sketch to scale. A deviation was made in width of the shoe, because he was compelled to hold the length to a maximum of 5 ft. Other deviations were compelled by these requirements of contour.

» «

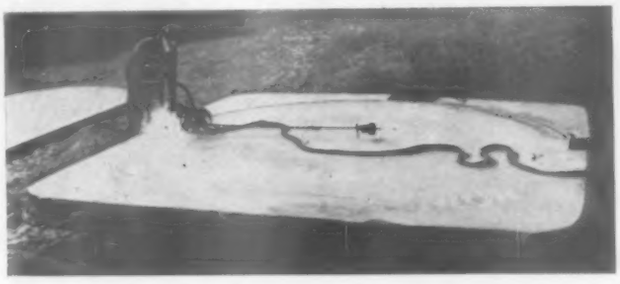
Welded Gantry Crane Is 25% Lighter in Weight

★ A specially constructed, all-welded gantry crane was recently completed by Harnischfeger Corp., Milwaukee, Wis. This gantry crane was designed for lifting the gates on a large western dam. An illustration shows this crane in the early stages of construction. Welding permitted a saving in weight of about 25% and an appreciable increase in strength. Where necessary all units were locally stress-relieved.

In welding this 20-ton crane, which is 22 ft. high, Harnischfeger used P&H-Hansen welders and 1250 lbs. of ¼ in. "DH" electrodes. The welds thus produced have a tensile strength of 60,000 psi., an elongation of



Welding permitted a weight saving of about 25% in building this gantry crane.



Flame-cutting a circular plate 165¼ in. in diameter for huge flywheel.

25 to 35% in 2 in., and a resistance to impact of 40-60 ft.-lbs. Hoists were used as welding positioners wherever possible to permit easier and more efficient spotting of units to be welded. Manufacturers building machines for lifting, lowering and moving loads are adopting the use of all-welded steel because of increased mobility due to lighter weight and greater strength of all-welded construction.

» «

Bronze Welding Helps the Automotive Repair Shop

By A. F. MORTON

★ Several excellent examples of automotive repairs handled successfully by bronze welding are shown in Fig. 1 to Fig. 5 inclusive. This versatile process has saved our customers a tremendous sum of money in recent years. The captions are self-explanatory.

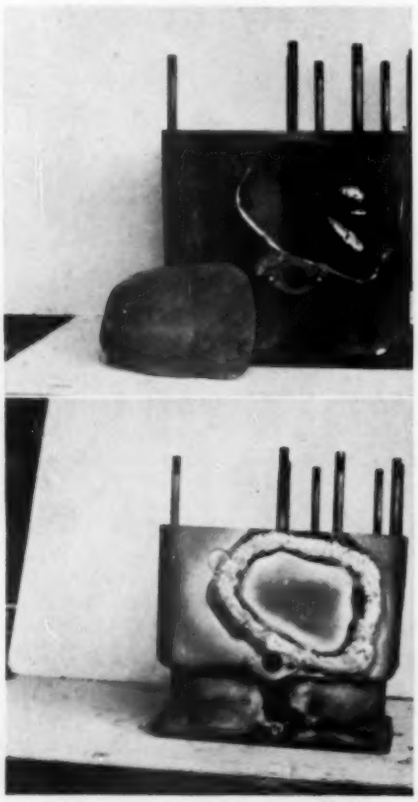


Fig. 1A—Patch in broken water jacket cut out by oxy-acetylene torch.

Fig. 1B—Patch has been bronze welded into jacket. No preheating used.

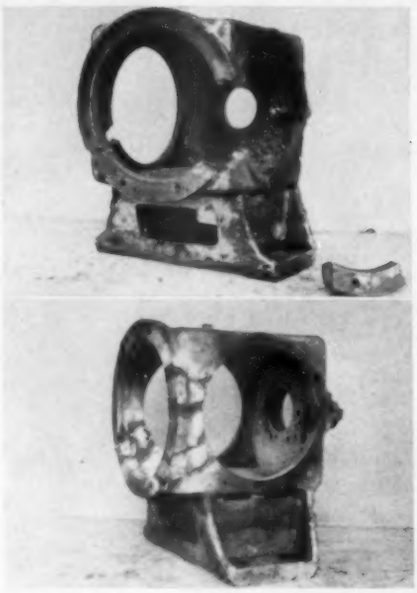


Fig. 3A—Angle drive housing broken in 3 places.

Fig. 3B—Edges were ground and then steel grit blasted before bronze welding. No preheat.

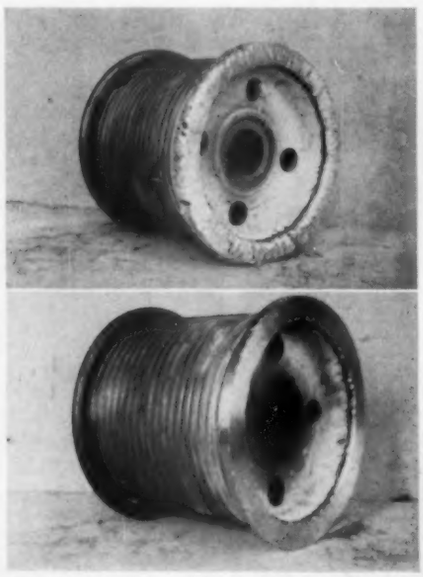


Fig. 4A—Air hoist cable drum with worn flange and broken parts repaired with bronze. No preheat.

Fig. 4B—Finished drum machined to size and ready for service.

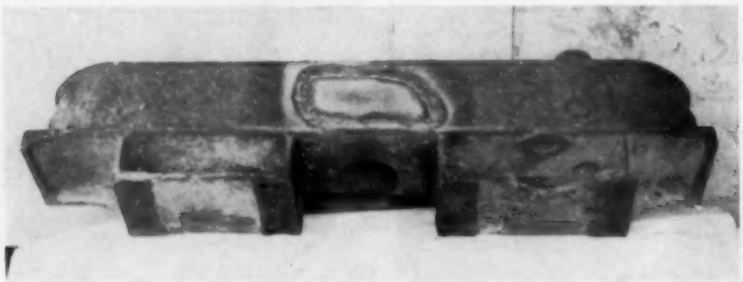
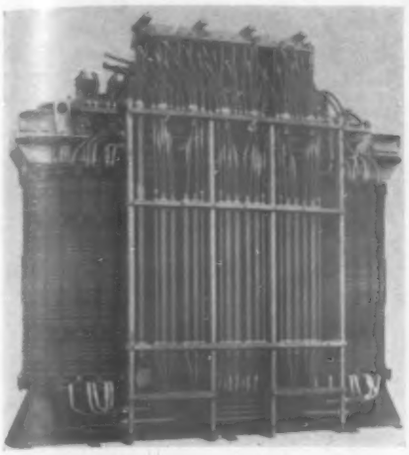


Fig. 2—A new steel plate was bronze welded to broken radiator casting.

Fig. 5A—In 2 yrs. this drive shaft and differential housing broke 4 times in 4 different places.

Fig. 5B—Every time it broke, the housing was bronze welded. Now it has several welding "scars."

Welding a pipe flange in one of Great Britain's railroad shops.



This 40,000 kva. transformer has more than 400 Sil-Fos brazed joints.

Six Million Silver-Brazed Joints Without a Failure

★ Low-temperature brazing alloys are used extensively in constructing transformers. More than 6 million copper-to-copper joints have been made in the last few years on General Electric transformers and to date there has not been a single field failure. These joints are mainly between taps and coil conductors and between copper bars.

Incandescent carbon heating is used principally in making these brazed joints and the alloy, which is a silver, copper, phosphorus composition, is placed in strip form between the parts joined or, in some joints, is fed in from a rod by hand.

Lap joints show less resistance than the copper itself, while butt joints show a very slight increase in resistance.

» «

Farm Gate-Way Ornament

★ Shown in the illustration is a decoration fabricated entirely by arc welding, except for the bull's-head, at a total cost of only $18. The bull's-head was imported and was fashioned entirely by hand forging. It is reported that without the aid of the electric arc the cost of this piece of ornamental iron work would have been much higher. Electric welding allowed extremely close work which would have been impossible with conventional methods of metal working. Welding was done with equipment supplied by The Lincoln Electric Co.

Arc welded gate-way ornament. Photo (Lincoln Electric Co.).

» «

Metal Spraying of Tin

By H. V. KAEPPEL

★ The metal spraying of pure tin is found in the coating and surfacing of equipment employed in processing and handling of food, dairy products, and other substances intended for human consumption. Tin and its corrosion products under these conditions are non-toxic physiologically. Such applications have for their purpose the formation of a resistant and protective covering over the underlying metal, thus preventing contamination of edible product. Sprayed tin coatings can be readily applied to a wide variety of metals including copper, steel, cast-iron, bronze, brass, etc., after the surface has first been thoroughly cleaned and roughened by sand or steel-grit blasting.

The spray process has been found useful in the dairy industry for tinning such items as copper milk tanks, mixers, coils, and evaporators. An excellent application is that of spray-tinning the inside surfaces of iron milk-filter castings which are difficult to coat successfully by means of the hot-dipping or wiping methods. This is true of all cast-iron parts when handled by the latter processes, for the reason that highly molten tin is very reluctant to "wet" the surface of this metal completely and properly.

Illustrated in Fig. 1 is a cast-iron milk filter of 30 in. diameter. All interior surfaces (area 16 sq. ft.) of these castings were sprayed with one .003 in. thick coat of zinc and then with 10 oz. per sq. ft. of pure tin to give a total thickness of coating of .012 to .015 in. Preparation preliminary to metal spraying consisted of blasting with a hard, angular sand to clean and roughen the surfaces properly to obtain a satisfactory bond between the sprayed metal and the casting. After spraying, the tin coating was wire-brushed with a power wheel and then polished to smooth the matte surface characteristic of all sprayed deposits. This provided a surface that could be readily cleaned in service, an important requirement for equipment of this kind.

Fig. 1—Cast-iron milk filter sprayed first with zinc, then with tin.

Fig. 2—Mixing tank for cheese. Sprayed with tin.

All sizes of vats and tanks employed as mixers (Fig. 2) for products such as cottage cheese are satisfactorily tin-coated in this same way. A size of mixer commonly used is about 3 ft. square in section by 4 ft. deep and usually the construction, including the paddle or agitator, is of cast iron.

The interiors of many pumps handling vegetable and fruit juices have been treated in this manner. A typical job involved the tinning of the case, end plates and rotors of a gear-type pump (Fig. 3). Sand blasting was used to clean and prepare the surfaces, which were coated with .003 in. of zinc followed by .010 to .012 in. of tin. The coating was then smoothed by wire brushing, and polished with emery. The rotor bearings of this pump were corroded and undersize. To remedy this condition stainless steel was sprayed on these wearing surfaces, using the conventional rough thread cut bond.

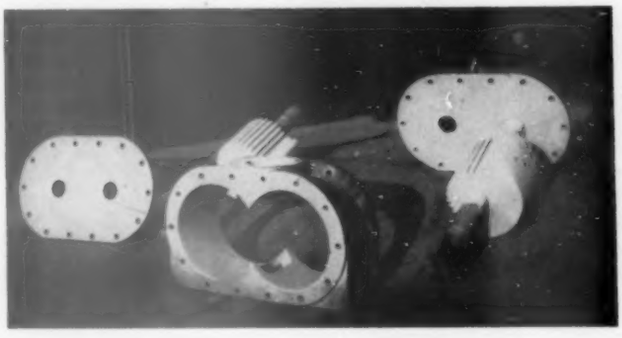


Fig. 3—Gear type pump protected with coating of tin applied by metal spray gun.

New Product Developments

Two New Marquette A-C. Welders

★ The Model 400 BT A-C. arc welder is announced by Marquette Mfg. Co., Minneapolis, Minn. This new welder (a 350-amp. machine) supplements the present line of Marquette welders.

The Model 400 BT has a range from 30 to 350 amp. with a separate tap for each of the 19 heat stages. The amperage is plainly marked beside each tap, thus eliminating confusion and speeding up operation. There are no moving parts. The transformer will operate at full capacity continuously and

Marquette Model 400 BT a-c. arc welder.

deliver a stable arc at any heat stage. Model 400 BT is listed under Re-examination Service of Underwriters' Laborotories, Inc.

Another recent addition to the Marquette line of a-c. arc welders is the Model 300 BT, which is similar to Model 300 B but is mounted on a new type of truck. This truck is designed for use where quick mobility is important. The handle and pivot on the leading truck make transportation about the shop easy. All four wheels have roller bearings and Alemite fittings. Handle and pivot bearings are Oilite equipped.

Model 300 BT is also listed by Underwriters' Laboratories, Inc. It has a range from 20 to 250 amp. Amperage is plainly marked beside each tap. There are no dials or moving parts.

» «

"Glyptal Gray" Prevents Adhesion of Weld Spatter

★ "Glyptal 1294 Gray," a recent addition to General Electric's line of welding accessories, was developed to meet the need of fabricators for a material which, when applied to metal to be lap welded, would prevent corrosion where the plates overlap. It is a pigmented version of the previously announced "Glyptal 1294 Clear" and will prevent adhesion of weld spatter when applied to parts before welding. Also serves as an excellent base for painting.

"Glyptal Gray" can be sprayed or brushed and the work can be left exposed to the atmosphere until fabrication is completed. The new product should appeal to shipbuilders, pipe and tank manufacturers, and other fabricators which make use of lap-welded joints. Such fabricators can order their steel coated with "Glyptal Gray" at the mill and then store it until needed.

» «

"Electroweld" Spot Welder

★ The Electric Arc Cutting & Welding Co., 152 Jelliff Ave., Newark, N. J., has brought out a new type of spot welder, wherein the welding head, control and automatic switch are in a compact unit. The equipment is arranged to be hung from a trolley or portable crane to handle work that is clamped to a form or jig or not practical to move for other reasons.

Electric Arc has brought out this hanging model as a portable machine with leads, but with a power demand of only 5 to 10 hp. Leads for this "Electroweld" unit are as

Welding head, control and automatic switch form a compact unit.

handy as lamp cord and very little larger. Claimed to be ideally suited for the general jobbing trade. Machine is guaranteed electrically and mechanically.

» «

Spatter-Nox Cuts Weld Cleaning Time

★ A liquid preparation under the trade name of Spatter-Nox has been introduced on the market to aid in reducing weld cleaning costs. This liquid can be brushed or sprayed over the area to be welded. Among the advantages claimed for Spatter-Nox are: Reduces weld spatter 50%; cuts labor cost of cleaning; cuts slag cleaning time 50%; permits a more stable arc; does not change physical properties of weld; acts as a rust inhibitor; and can be easily applied.

Spatter-Nox is being distributed nationally by Universal Power Corp., 4300 Euclid Ave., Cleveland, Ohio.

Left half of this welded section was treated with Spatter-Nox before welding.

» «

A Double-Duty Welding Unit

★ The Young Sales Co., Inc., of Milwaukee, Wis., has recently introduced a double-duty gas and electric welding unit which combines the P&H-Hansen 150 amp. portable welder made by Harnischfeger Corp., and

Combination welding unit features portability and economy.

gas equipment manufactured and developed by Young Sales Co., Inc.

The electric welding generator is coupled to a Wisconsin air-cooled motor mounted on a standard P&H trailer. Used in connection with this unit, is a complete gas welding and cutting equipment. A model 6-P Sight Feed acetylene generator is used and a special bracket is provided to carry either a large or small tank of oxygen.

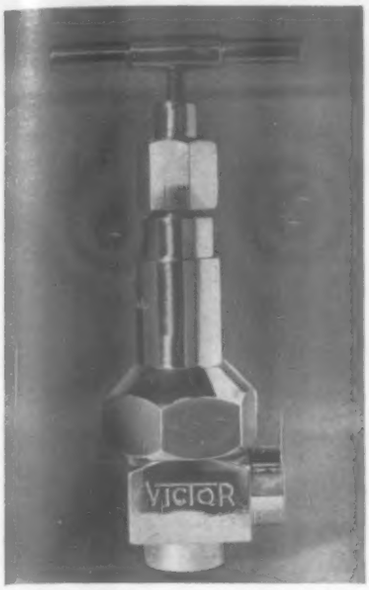
Further information may be obtained by writing either to Harnischfeger Corp. or Young Sales Co., Inc., both of Milwaukee, Wis.

» «

Salt Tablet Dispenser

★ A new type of dispenser for supplying workers exposed to high temperatures with salt (sodium chloride) tablets to prevent heat sickness is announced by Davis Emergency Equipment Co., 55 Van Dam St., New York City. This new salt table dispenser is made of black plastic, chemically inert to salt. When a knob at the bottom is turned in either direction, a single tablet is dropped into the palm of the hand. There are two sizes, one holding 1000 tablets and one holding 500.

Salt is needed by men working in temperatures above 90 deg. F., either indoors or out of doors, because depletion of body salt through excessive perspiration may cause heat sickness, which is characterized by cramps, nausea, dizziness, and general muscular exhaustion. From 4 to 6 salt tablets (10-grain) a day should be taken to replace lost body salt, it is stated.



Adjustable pressure relief valve (up to 600 psi.) for high-pressure gas applications.

A New High-Pressure Adjustable Relief Valve

★Victor Equipment Co., Welding Equipment Division, 844 Folsom St., San Francisco, Calif. is marketing an adjustable pressure relief valve for operating pressures up to 600 psi. Both inlet and outlet are 5/8-in. No. 18 thread with flat seats. Sturdily constructed, simple in design, and accurate, these adjustable high-pressure relief valves were originally designed to meet the requirements of oil refinery laboratories. The manufacturer claims that the reliability of these relief valves make them suitable for a multitude of high-pressure gas applications.

» «

Heavy-Duty Welding and Heating Blowpipe

★Numerous metal-working operations such as forging, forming, straightening, bending, and pressing can be effectively and economically performed with the aid of the intense, localized heat of the oxy-acetylene flame. Of late, the usefulness of the oxy-acetylene flame for these "smithing" operations has been greatly increased by the availability of a large-capacity heating blowpipe. This blowpipe, distributed by The Linde Air Products Co. and known as Oxweld (Type W-26) Heavy-Duty Welding Blowpipe, is for welding and heating ranges above those which can be handled by ordinary blowpipes. It delivers a tremendous amount of heat to a localized area, and does this so quickly that metal-working and heat-treating can be accomplished at top speed.

Extensions for the welding head are available for extra-heavy work, doing away with necessity for heat shields. The operator works in comfort, away from the source of heat, and finds the blowpipe, even with the extension, easy to handle because of its well balanced design.

Its applications cover a wide range, including fabrication of tanks and pressure vessels, locomotive boilers, straightening and bending ship plate, wrinkle-bending large-diameter pipe, and similar heavy work. Can also be used for lighter work as well as for certain flame-hardening operations.

» «

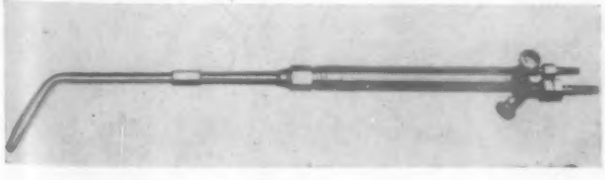
Hard-Surfacing Powder for Application with Carbon Arc

★"Surfaceweld A" is a fine grained alloyed powder which can be applied with the carbon arc to give a smooth, dense, hard (abrasion-resistant) surface. It can be applied in a very thin layer if desired. This material, when properly applied, will give a coating with a hardness of approximately Rockwell C154. This hardness will vary somewhat depending upon amount of admixture with base metal to which it is applied.

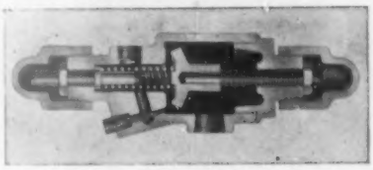
This alloy develops its full hardness in the deposited condition, maintains its hardness at high temperatures and resists scaling at high temperatures, according to the manufacturer—Lincoln Electric Co., Cleveland, Ohio. The deposit cannot be softened by annealing. Corrosion resistance will compare favorably with that of stainless steel.

Its resistance to abrasion is excellent. One of its big advantages is that it can be applied in very thin and extremely smooth layers. The limit of the thinness of a layer is governed, from a practical standpoint, when the deposit becomes so diluted with the base metal that "Surfaceweld A" will not flow properly. A deposit as thin as .025 in. can be applied to light metal, such as 12 to 20 gauge.

Following procedure is given for application: "Spread powder evenly over area to be surfaced and to a depth of 2 to 3 times desired thickness of deposit. Use a sharp, well tapered carbon with negative (normal) polarity and fuse down with a weaving motion. The exact heat required will depend on size of work. Use enough heat to obtain a free-flowing puddle, but not enough to dig into base metal. Whenever possible weave the full width of desired deposit and build to desired depth in one pass. If more than one pass is required the work must be kept hot. Avoid heavy deposits." "Surfaceweld A" is shipped in 1 lb. and 15 lb. cans. For any further data, write to Lincoln Electric Co., 12,818 Coit Rd., Cleveland, Ohio.



Oxweld (Type W-26) blowpipe for heavy-duty welding and heating operations.



Improved type of Murray-Lorge safety valve.

Automatic Safety Valve for Welding and Cutting Gases

★D. J. Murray Mfg. Co., Wausau, Wis., has developed an improved type of safety shut-off valve for acetylene lines. It is being sold under the trade name of Murray-Lorge Safety Valve and operates on the principle of equalized pressure. This valve can be used as a safety appliance on any line where a flexible hose is employed to carry liquids or gases under pressure. The device is compactly built and can be used with little or no maintenance cost for a long period of service, it is claimed.

» «

"Phosco" Brazing Alloy

★A low-temperature phosphorous-copper brazing alloy marketed under the trade name of "Phosco," is announced by United Wire and Supply Corp., Providence, R. I. This alloy is recommended for all types of joints between copper, bronze, nickel-silver, brass and other non-ferrous metals.

"Phosco" alloy becomes plastic about 1150 deg. F. and flows freely at its working temperature of 1300 deg. F. It is said to be exceptionally free flowing and because of its high phosphorous content it is self-fluxing, the phosphorous acting as a deoxidizing agent. This self-fluxing property reduces cleaning time, and gas and labor costs. Electrical conductivity of "Phosco" brazed copper parts is said to be about 95% of the conductivity of the parent metal. Owing to the freedom from zinc in its composition, it is said to offer a high degree of resistance to the common corrosive agents. Laboratory tests of lap-brazed "Phosco" joints range from 35,000 psi. for soft copper to 55,000 psi. for commercial bronze. Corresponding values for butt-brazed joints range from 32,000 psi. (soft copper) to 50,000 psi. (commercial bronze). Fatigue tests indicate that "Phosco" brazed, copper, bronze, and brass, parts will always fail in the parent metal rather than in the brazed joint.

» «

ANOTHER 18,000-TON WELDED TANKER—The third of The Atlantic Refining Company's new 18,000-ton welded tankers will be launched at the yards of the Sun Shipbuilding and Dry Dock Co., Chester, Pa., on July 29. The new vessel will be christened by Mrs. E. J. Henry, wife of a vice-president of The Atlantic Refining Co., for whom the vessel will be named. Like her sister ships, the S.S. J. W. VAN DYKE and the S.S. ROBERT H. COLLEY, both of which were commissioned in 1938, the S.S. E. J. HENRY has an overall length of 541 ft. 5 in. and a beam of 70 ft. Cargo capacity is 156,000 barrels, or 6,552,000 gallons.

Butt-Joints in Steel Plate

(Continued from page 32)

first layer; (3) Deposits a relatively thin second layer with a fast transverse weave to normalize, diffuse and refine the layer beneath. Adoption of this technique similarly treats each preceding transverse lamination as each layer is deposited.

The remainder of the groove should now be filled up with other relatively thin layers, using the transverse weave technique similar to that used on the second layer (Fig. 4). This can be done without pulling up the sides of the vee at the end of each traverse, since this is not necessary. A very slight pull-up on the sides may sometimes be desirable, with an instant of hesitation, in order to pull the molten steel to the sides, wetting them and filling in to make the surface flat, or what is still more desirable, slightly concave. Surface of the layers should never be convex.

In making overhead vee-joint butt welds, the same technique should be used as that described for vertical welds. A welder may use a little less heat in the overhead work until he is skilled in the technique, when he will find he can weld overhead with the same heat as for vertical welds. The flat position vee-joint may also be put down in a similar manner, except that the first layer is put in without whipping, but with a little pull up the side of the bevel at the end of each transverse, making the arc describe a path like a shallow U. It would seem scarcely necessary to add that the same technique suggested for the vee-joints, with slight modifications, may be used in welding the J-shaped joints in heavier plate, and also for vertical and flat overhead fillets, the technique is especially suited for fillets larger than can be successfully made with a single string bead.

The amount of energy used in the arc is an important factor in making this welding technique a complete success. Sufficient heat should be used to get enough penetration to make the weld metal fuse to the parent metal, yet the pool of molten metal should not be too large. After the first or second layer the metal should be observed freezing out from the side, when the arc has been shifted to the opposite side in the process of weaving. Succeeding passes will then have a maximum diffusing, refining, and normalizing effect.

News of the Industry

R.W.M.A. Members Meet at Warren, Ohio—Members of the Resistance Welder Manufacturers' Association were guests of the Taylor-Winfield Corp., Warren, Ohio, at the regular monthly meeting, Friday, June 23. A full day's program began with an inspection tour of the production and engineering facilities of the Taylor-Winfield plant.

Before gathering for lunch at the Trumbull Country Club (Warren) an executive committee meeting was held. This was followed during the afternoon with golf for those so inclined and other diversion for those not interested in such physical activity.

Dinner was served at the club with John D. Gordon acting as toastmaster in the absence of Walter Anderson, president of R.W.M.A., and vice-president of Taylor-Winfield Corp. Members of the Association were welcomed by Mayor Dan Gutelius of Warren. He was followed by B. N. MacGregor, president of the Warren Chamber of Commerce.

After-dinner speakers included Edmund von Henke, of American Electric Fusion Corp., who enthusiastically pointed out that one accomplishment of the Association was the forging of a close bond of friendship among its members. Geo. Sieger, of S-M-S Corp., indicated many avenues of co-operation between the manufacturing and accessory groups. Activities and accomplishments of the group were outlined by Geo. Fernley, secretary.

In commending on the future needs of the Association John Gordon said, "The free interchange of information and close harmony of members in promoting the interests of this group as a whole will advance the separate interests of each individual member." G. A. Cutter, of Thomson-Gibb Electric Welding Co., and R. G. English, of Swift Electric Welder Co., were other scheduled speakers but they were unable to attend.

Indicative of the forward-looking program and aims of the Association, was one of three banners donated by Mr. von Henke which read; "Your Can Boost Industry by Charging Fair Prices and Investing Part of Profits in Research and Customer Aid."

Personals

Charles H. Beard has been appointed general traffic manager of the operating companies of the Union Carbide and Carbon Corp., 30 East 42nd St., New York City.

» «

J. T. Gillespie, Jr., has been appointed assistant to Thomas B. Hasler, president of Wilson Welder and Metals Co., Inc., 60 East 42nd St., New York City. Mr. Gillespie, whose headquarters will be in New York, was formerly assistant manager of the Central Division of Railroad Sales of Air Reduction Sales Co. in Chicago. In his new duties he will handle promotional sales activities in co-operation with I. B. Yates, general sales manager of Wilson Welder and Metals Co., Inc.

» «

Thomas V. Brooke has been appointed sales engineer in the Chicago office of The Lincoln Electric Railway Sales Co. His appointment became effective June 12. Mr. Brooke is a graduate of Virginia Military Institute and for several years has been associated with The Lincoln Electric Co. as a research engineer. In this position, he has gained valuable knowledge and experience in the design, manufacture and application of arc welding equipment and electrodes. The office of The Lincoln Electric Railway Sales Co. in Chicago is located at 310 South Michigan Ave.

Trade News

Denver Oxygen Co., 10th and Lawrence Sts., Denver, Colo., has been appointed a distributor for Stulz-Sickles Co., Newark, N. J. This distributor will handle the full line, including Manganal Bare and Tite Kote welding electrodes, applicator and wedge bars and Seaco hard-surfacing welding electrodes.

» «

G. E. orders up 32%—Orders received by General Electric Co. during the first six months this year amounted to $169,071,646, compared with $128,223,823 for the same period last year, an increase of 32%.

» «

H. A. Webb, 4038 Colgate St., Houston, Texas, has joined the staff of the Harnischfeger Corp., Milwaukee, Wis., to cover the Texas territory, representing P&H-Hansen welders and Smootharc welding electrodes.

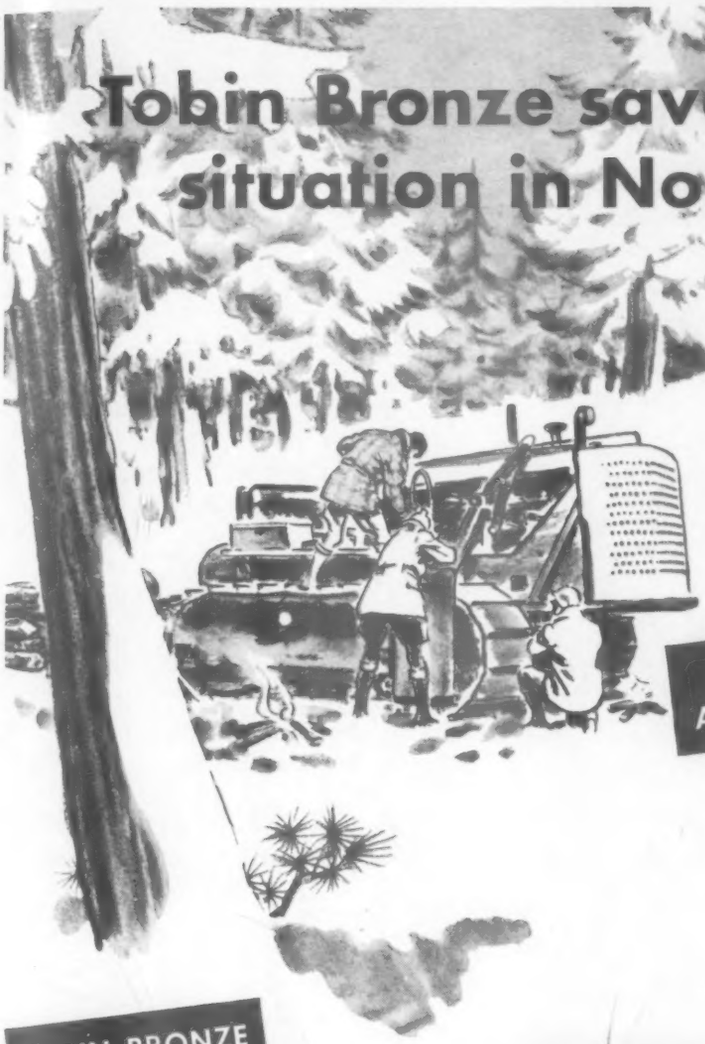
» «

The 1939 Machine Tool Show, will be held in Cleveland, Ohio, October 4th to 13th, according to the National Machine Tool Builders Association. Both in number and range of exhibits and in improvements in performance and design of machine tools, this year's show is expected to surpass the last machine tool show which was held in Cleveland in 1935. The show will be housed in Cleveland's $15,000,000 Public Auditorium, which contains over six acres of exhibition space.

» «

Harnischfeger Corp. Appoints Dealers—Harnischfeger Corp. of Milwaukee, Wis. has appointed Parsons Bros., 31 E. Washington Ave., Bridgeport, Conn., as exclusive representatives for P&H-Hansen welders and Smootharc welding electrodes in a local territory. Buford Bros., Inc., of Nashville, Tenn. will have representation of P&H-Hansen welders and Smootharc welding electrodes in the Nashville territory on an open

Tobin Bronze saves desperate situation in North Woods



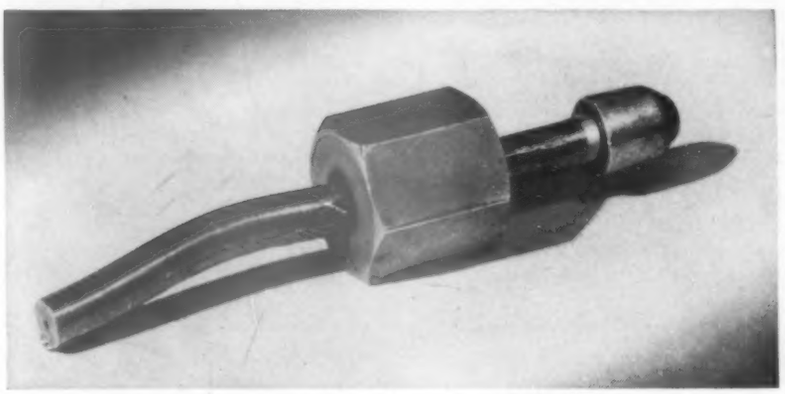
Another chapter in Tobin Bronze's "life-saving" history—by E. J. Morris, welding and Diesel engineer of The Pas Lumber Co., Saskatchewan

THE ACCIDENT

"This big Diesel 8 was lumbering through thick woods when a large stick jabbed through a fuel injector line. The break was in the worst possible place—down inside the nut which fastens the line to the injection pump. As these lines never fail in normal service, no spare was at hand and to make matters worse, our nearest repair depot was hundreds of miles away."

TOBIN BRONZE TO THE RESCUE

"We decided to try repairing the line with Tobin Bronze welding. In making the repair, the parts were ground cone shaped to allow almost complete penetration of bronze; alignment was secured by running a wire through the parts; and the weld made with Tobin Bronze. In about three hours, the machine was back at work and the welded line, which is subjected to pressures of 1800 to 2500 p.s.i., operated perfectly."



This is another instance proving the value of this Anaconda Welding Rod for difficult jobs on copper and copper alloys, steel and iron. Tobin Bronze carries the trade-mark "Tobin Bronze Reg. U. S. Pat. Off." in each rod. Look for this trade-mark and be sure you are getting the genuine. 39133

Visit the Copper & Brass Industry Exhibit in the Metals Building, New York World's Fair—1939.

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ANACONDA

Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

Technical Literature

We have listed below brief reviews of new technical literature prepared by experts in the employ of welding equipment manufacturers. Any literature you may desire will be sent to you free of charge. Merely check or mark the serial number of the paragraph on the order blank at the bottom of the page. No obligation.

Resistance Welding Controls

(114) Square D Co. has issued bulletin WLD5 to assist the user of resistance welding. Educational treatment is employed, including a resume of resistance welding processes, types of machines and current controlling devices required. This bulletin should be helpful to users of resistance welding. Circuit diagrams are included for each type of application.

Simplified Pipe Welding

(115) Taylor Forge & Pipe Works has issued a four-page bulletin describing the new "Centring" WeldELL for making fusion welded pipe connections. This new pipe fitting has an integrally forged ring which automatically centers the elbow ready for welding and eliminates need for backing ring.

Welding Positioner

(116) Cullen-Friestedt Co. has issued a four-page bulletin headed "Better Welds at Lower Cost," which describes its C-F Welding Positioner. With this device the assembly to be welded can be completed on sides, top and bottom with only one set-up on the positioner. The table can be tilted a total of 135 deg. from horizontal and can be rotated through a full circle regardless of angle at which it is tilted. Thus, all welds can be made in downhand position.

Metal Spraying

(117) Metallizing Co. of America, Inc., has a 26-page booklet available covering applications of metal spraying and listing equipment necessary. A new Propane-Mogul gun is described. This new gun is said to reduce gas costs and increase speed of deposits.

Electric Tool Catalog

(118) Independent Pneumatic Tool Co. has issued a 48-page catalog describing the 1939 line of Thor portable electric tools. This line includes universal type electric drills, saws, hammers, grinders and polishers.

Eye Protection Bulletin

(119) Mine Safety Appliances Co. has issued an eight-page bulletin on the subject of industrial eye protection, featuring advantages of the various types of M.S.A. protective lenses, goggles, helmets and shields.

Grinding Wheels

(120) Norton Co. has published a 76-page pocket-size booklet containing valuable technical data on grinding wheels and grinding technique. Simple sketches aid the reader to understand what takes place when grinding wheels are used in finishing operations. A valuable booklet for the shop man.

Amsco Manganese Steel Catalog

(121) The American Manganese Steel Division, Chicago Heights, Ill., has just issued a 64-page catalog which contains over 400 illustrations showing manganese steel castings for every industry using equipment exposed to impact and abrasion. The reader will find the answer to the question: "What Is Manganese Steel?" The catalog covers the origin and physical properties and tells why manganese steel is the "toughest steel known." Copies of this catalog may be had by writing to the manufacturer.

THE WELDING ENGINEER July, 1939

506 So. Wabash Ave., Chicago, Ill.

Please send me the literature as checked [X] on the list below:

114 ☐	117 ☐	120 ☐
115 ☐	118 ☐	121 ☐
116 ☐	119 ☐	

(To be sure of receiving literature ordered please indicate below your company affiliation and position.)

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Position _____

basis. R. S. Armstrong & Brothers Co. has been appointed agents for P&H-Hansen welders and P&H Smootharc welding electrodes on an open basis in Georgia and South Carolina. This latter firm is located at 676 Marietta St. N.W., Atlanta, Ga.

» «

Union Carbide Group Moves Into New Cleveland Offices—The Cleveland district offices of The Linde Air Products Co., Carbide and Carbon Chemicals Corp., and Haynes Stellite Co., all of which are units of Union Carbide and Carbon Corp., are now located at 1517 Superior Ave., Cleveland. The entire building is occupied by sales and process service departments of these companies. District managers are H. H. Dyar, for The Linde Air Products Co., E. E. Fogle, for Carbide and Carbon Chemicals Corp., and F. P. Shephard, for Haynes Stellite Co.

» «

The American Manganese Steel Division of The American Brake Shoe & Foundry Co. has expanded its main plant at Chicago Heights, Ill. Six additions and a new administration building were included in this improvement program.

Current Reviews

New Book on Blueprint Reading

A new book entitled "Simple Blueprint Reading with Particular Reference to Welding and Welding Symbols" is announced by The Lincoln Electric Co., Cleveland, Ohio. While "Simple Blueprint Reading" has been compiled and published primarily for welders, it contains information of value to anyone concerned with mechanical construction. Its object is to provide information and instruction on the reading of blueprints and drawings. The book affords a basis for study which, together with practice in the actual reading of drawings, will aid the student to attain proficiency in this important subject.

Since the most successful and economical use of arc welding requires ability on the part of the welder and other mechanics to carry out the wishes of the designer, it is essential that the welder and such mechanics be able to read and understand the various lines, symbols and other markings which the draftsman employs to convey his ideas. By means of the new book the welder can learn with a few hours' spare-time study what it may take many months to pick up in the ordinary course of everyday work.

"Simple Blueprint Reading" takes the student in easy stages to a mastery of this subject. While it is not intended to be an exhaustive treatise on blueprint reading, the book affords a sound basis in fundamentals. By applying what he learns, and by referring to the book when questions arise, the student will be able to understand the language of the draftsman.

The book includes among other important subjects: Development of the basic weld symbol, the arrow, method of indicating weld position; method of indicating type

of weld, size and shape of weld, length of weld and other necessary information; analysis of complete weld symbol and its use; sections of over 35 different welds with their corresponding symbols; examples of the previous instruction drawings with welding symbols added; special symbol instruction drawings, discussion.

"Simple Blueprint Reading" contains 140 mimeographed pages, 8½ in. by 11 in., and is bound in durable paper. It is available from The Lincoln Electric Co. at $0.50 per copy, postpaid anywhere in the United States; $0.75 elsewhere.

Recent Patents

Welding Torch

2,157,269. Carl R. Richter, Schenectady, N. Y. Filed May 22, 1936. Issued May 9, 1939. This invention is concerned with a torch intended for use with city gas or other low b.t.u. gases. However, by making slight adjustments, the torch may also be used with high b.t.u. gases such as acetylene and oxygen. Heretofore, in attempts to use low b.t.u. gases for welding it has been found that, with ordinary equipment designed for use with high b.t.u. gases, there was inadequate mixing of the gases. The torch of this patent has a nozzle opening and two needles, one a welding needle, and the other a cutting needle, the forward end of the welding needle being closed, and the cutting needle being located within the welding needle. Suitable needle valves permit adjustments to utilize different types of gases. Both needles are removable and may be replaced.

» «

White Metal Electrode

2,157,447. Cliff A. Williams, Dallas, Tex., assigned to Stanley D. Bowles, Dallas, Tex. Filed Aug. 25, 1937. Issued May 9, 1939. The weld metal composition of this patent is intended primarily for deposition on surfaces made of white metal or pot metal as it is known in the trade. The composition is such that when the weld is polished down the joint will be practically indiscernible. Particular utility appears in the welding of aluminum purposes. These alloys contain a mixture of zinc, copper, lead or tin, and other elements. White metal alone does not fuse satisfactorily it is claimed and therefore it can not be used as a welding rod. The inventor adds a small amount of bicarbonate of soda to white metal to impart better fusion qualities to the metal.

» «

Electric Welding

2,157,769. Antonio Longoria, Lakewood, Ohio, assigned to Niagara Wire Weaving Co., Ltd., Niagara Falls, Ontario, Canada. Filed Nov. 19, 1937. Issued May 9, 1939. The object of this patent is to provide a machine for welding wires of small diameter, such as the wires in belts for Fourdrinier paper making machines. Such wire is usually thin and soft. Difficulty has arisen in welding such wire, since excessive heat will burn the metal, while insufficient heat will give a poor joint. The invention uses a direct-current welder. The wire to be welded rests upon a plate which is the positive side of the current supply. The negative terminal is connected to the welding electrode. The circuit is such that no weld is made at the time the electrode contacts the work, but upon withdrawal of the electrode, an arc of sufficient intensity to effect a weld is drawn. The circuit includes a low resistance, high-inductance coil in one line and a non-inductive rheostat in the other line of the circuit.

» «

Welding Alloy Sheet Liners

2,158,799. Louis J. Larson, Milwaukee, Wis., assigned to A. O. Smith Corp., Milwaukee, Wis. Filed Mar. 4, 1936. Issued May 16, 1939. To obtain a seam of high corrosion resistance in a welded liner for pressure vessels, or other tanks made of low-carbon steel, the inventor uses a special alloy welding rod. The weld is made in two passes. The first layer at the bottom of the groove is applied from an electrode having a higher alloy content than that of the alloy liner sheets. The second or top layer is applied from an electrode having an alloy content approximating that of the alloy sheets. Specific application has been in the welding of liner sheets of chrome-nickel steel approximating 18% chromium and 8% nickel. The electrode for the bottom layer in welding this alloy has a content of 24% chromium and 12% nickel. The top layer uses an alloy of 18% chromium and 8% nickel. The additional alloy content of the first welding rod insures that the deposited metal, after dilu-

have everything good bronze rods need

Successful bronze welding requires that the weld metal effect a firm, strong bond with the parent metal, with complete and thorough penetration. The molten metal must flow easily and smoothly, with minimum fuming during deposition, making a dense, sound deposit.

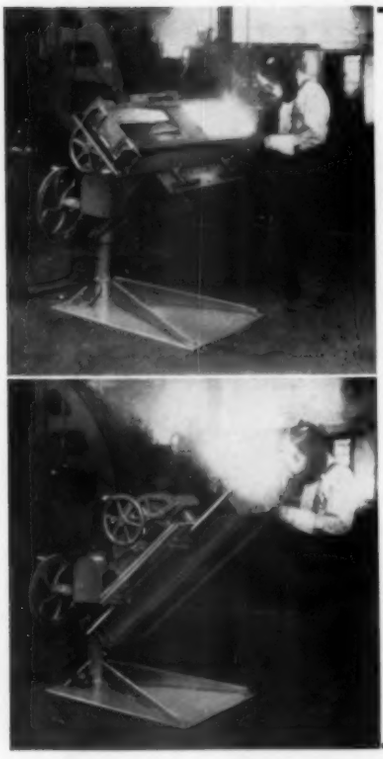
Titan Bronze Welding Alloys possess all these necessary qualities **in highest degree.** Use of only virgin raw materials for ingredients, precision manufacturing methods, plus the double deoxidation process for eliminating fuming, combine to assure finest obtainable welding qualities.

PENN BRONZE—a general-purpose rod, melting at 1620° F. Tins readily and uniformly on galvanized, malleable or wrought iron, as well as steel, brass, bronze and any other non-leaded metal with melting point above 1850° F.

TITAN MANGANESE BRONZE — especially adapted to production of tough, hard deposit. Particularly recommended for cast-iron repairs, where extremely dense, non-porous weld is essential.

May we send samples and literature?

Titan Metal Manufacturing Co.
Bellefonte, Pennsylvania



WELDING POSITIONER

•

BETTER WELDS

AT

LOWER COST

Table tilts 135° from horizontal.
(See Lower Illustration)

Table can be rotated 360° when tilted at any angle.

Table is removable if desired for special requirements.

2,500 lb. and 6,000 lb. capacity.

Write for Bulletin WP-17

CULLEN-FRIESTEDT CO.
1309 So. Kilbourn Ave. Chicago

tion with the plain carbon steel from the vessel wall, approximates the composition of the liner sheet.

» «

WELDING TEE

2,157,274. JAMES HOWARD WILLIAMS, Providence, R. I., assigned to General Fire Extinguisher Co., Providence, R. I. Filed April 27, 1937. Issued May 9, 1939. A welding tee is provided which has a wall thickness greater than the thickness of pipe to which it is to be welded. The tee is such that an aligning tool may be applied externally to the pipe and the tee and accurate alignment of their inner surfaces may be thus effected. The tee is made from a section of pipe having an extra thick wall for its internal diameter and it has a nozzle drawn from the wall of the section. The edge of the nozzle, as well as the edges of each leg of the tee, is chamfered for welding.

» «

WELDING BLOWPIPE

2,157,331. HARRY S. GEORGE, Massapequa, N. Y., assigned to Union Carbide and Carbon Corp., N. Y. Filed Dec. 24, 1936. Issued May 9, 1939. In multiple-tip oxy-acetylene blowpipes, a part of the oxygen used is drawn by aspiration from the atmosphere around the nozzle into the combustion zone. Usually the nozzle is tapered toward its tip so as to facilitate the aspiration of air and its proper mixing with the flame, for much of the air is drawn into the flame along the surface of the nozzle. Under some conditions of operation objectionable effects are created by the flame reflecting or reverberating back around the nozzle.

Among the causes of such reverberation are: the shape of the object being treated; operating in a confined space; directing the flame normally against the object; and combinations of these causes. With multiple-tip blowpipes these effects are increased. The back pressure of the reflected flame interferes with the aspiration of the atmospheric oxygen. Furthermore, the nozzle tends to become overheated and causes pre-ignition or so-called back-firing of the mixed gases within the nozzle. These difficulties are overcome, according to this invention, by the use of baffles, suitably constructed and located. The baffles are made of a highly conductive metal such as copper or a copper alloy; and they are located between and parallel to the nozzles. The baffles are located on the nozzle block.

The function of the baffles is two-fold: first, to obstruct the reflected flame and second, to decrease the area of the passageway around the extremity of the nozzle, thus increasing the velocity and pressure of the aspirated air drawn through the passageway. This latter effect counteracts the back pressure of the reflected flame, and also aids in cooling the nozzle by causing a more rapid circulation of cool air about the nozzle. The construction of the baffles is such as to effectively prevent overheating. Suitable cooling fins or artificial cooling elements may be used for this purpose.

» «

TANDEM FLAME WELDER

2,158,664. ARTHUR R. LYTLE and WILLIAM MORTON, Niagara Falls, N. Y., assigned to Union Carbide and Carbon Corp., N. Y. Filed April 23, 1935. Issued May 16, 1939. This interesting patent relates to successive layer welding of relatively thick plates. In the gas welding of both light and heavy steel plates, it is necessary to obtain a balance between a number of factors, such as thickness of plates, size of welding rod, heating capacity of torch, and speed of welding. For example, heat input into plate and welding rod must be balanced with heat capacity of plate and rod. In producing welded joints between thin plates this balance is readily obtainable, by a proper selection of equipment and suitable operation. However, for welding plates having a thickness of more than about ¾ in., the welding flame and rod, when properly proportioned to the thickness, become so unwieldly and heavy that their use is impracticable.

However, by employing the process of this patent, thick plates may be economically and efficiently welded. According to the patent, the usual groove or scarf is prepared to receive the filler metal. Then, concurrently, deposits of a sufficient number of superposed layers of weld metal are applied in tandem

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SAFETY GAS LIGHTER CO. (Est. 1901) LYNN, MASS.

fashion to completely fill the groove during a single pass of the welding mechanism. This mechanism consists of a number of welding units corresponding to the number of layers to be deposited, followed by a unit comprising one or more heating flames, to normalize at least the last deposited layer and to refine its grains.

The first welding unit preferably has one or more high-temperature preheating flames to preheat the plate metal and the surfaces of the groove ahead of the welding point. The successive layers are deposited by successive welding units which are arranged to deposit metal at points about 3 or 4 in. apart. During the progress of the welding, the welding flames are moved or oscillated back and forth across the groove and the deposited metal, to assist in a uniform delivery of heat to these parts and to control the contour and surface of solidified weld metal. Since the welding usually proceeds at a uniform speed along the groove, particularly in an automatic welding machine, the diameters of the successive welding rods should be progressively greater due to the greater width of the layer and the greater amount of filler metal that must be deposited within a given time.

Similarly, the amplitudes of oscillation of the successive flames and rod movements are progressively increased to cover the increased width of the weld. It is apparent that by this process each consecutive layer is deposited before the preceding layer has cooled below the critical temperature.

Classified Section

ADVERTISING RATES

Help Wanted — 75c per line, minimum 4 lines. Jobs Wanted — 4 lines free. Other Ads — $1.00 per line, minimum 4 lines. Count 8 words to line. Add 6 words for keyed address.

FOR SALE

FOR SALE—New Welding Cable, factory short lengths, rubber-covered, super-flexible—No. 2 at 18c ft.; No. 1 at 20c; No. 1/0 at 26c; No. 2/0 at 30c; also No. 3/0 and No. 4/0 in lengths from 50 to 125 ft. Metallizer gun $100. Address Jul-4, The Welding Engineer.

FOR SALE—Overstock genuine $6.50 value helmets with No. 10 lens at $3.50; also 200 amp. Lincoln welder at $135; and 300 amp. Lincoln welder at $210. Also 400 amp. at $275. In first-class shape. O. W. Maraska, 264 E. Ogden Ave., Milwaukee, Wis.

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BARGAINS—Demonstrator Arc Welders. Gasoline and electric drive. 30 days' trial. Easy terms if desired. Write Hobart Welder Exchange, Box U-791, Troy, Ohio.

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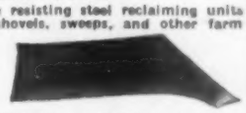

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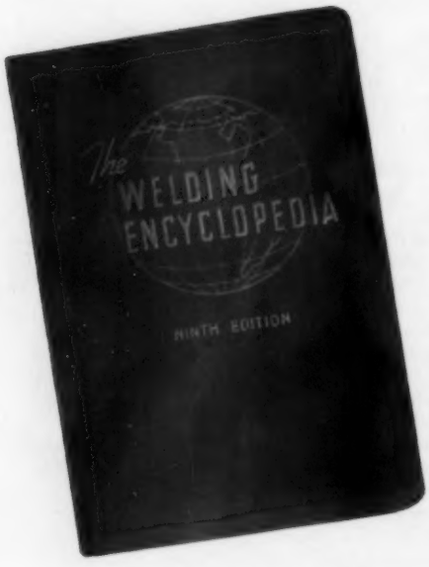

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What are the melting points of various metals?

What should the welder know about the structure of metals? of the composition of metal and non-metallic elements? about the Iron Carbon Diagram? See "Metallography."

What are the possibilities of Metal Spraying? Where can it be used effectively and what metals are adaptable to such application? What results may be expected? See "Metal Spraying."

In welding stainless clad steels, what procedure would you follow? Which side should be welded first?

How does a molten puddle of steel react under the three adjustments of the oxy-acetylene flame, i.e. neutral, oxidizing and carbonizing? What flame adjustments are recommended for the different metals?

Preheating—Can you name the three important reasons for its use? How does shape of piece govern point where preheating is applied?

How many codes are in existence which govern welding? To what specific types of welded fabrication do they apply? Name requirements of each?

What is indicated by results of reduced-section tension test? free-bend test? root-break test? side-break test? nick-break test? How is each made?

Where can silver solders be used to advantage? What metals are particularly adaptable to this process? Is joint design important?

What are content and designation of the most frequently welded metals? See "Specifications for Materials."

In welding Stainless Steels, what properties of the two general classes of these metals must be kept in mind?

In designing welded Structural Joints, what unit stresses (shear, tension and compression) are permitted under A.W.S. Building Code.

What kinds of metal and what shapes are best adapted to Flame Hardening? What advantages has it over furnace hardening?

What are the various forms of welded joints? What are root, leg, toe, face and throat of a weld?

Name qualification tests required for welding large steel tanks? What is the most economical design for open rectangular tanks?

What is the reaction in Thermit welding? Where is the process especially useful and what preparation is necessary?

What shop exercises are essential in a training course for oxy-acetylene welders? for arc welders? What shop equipment is necessary? See "Training Operators."

Welding Rods and Electrodes —Specifications for various A.W.S. grades are given as well as tensile requirements of all-weld metal coupons.

How are Welding Symbols used and how do they simplify detail drawings and shop blue prints?

What is "Arcronograph," "Avialite," "Blackor," "Borium," "Calobar," "Manganal," "Polygraph"? Who makes it? All leading trade names with manufacturer's name and address are given.

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